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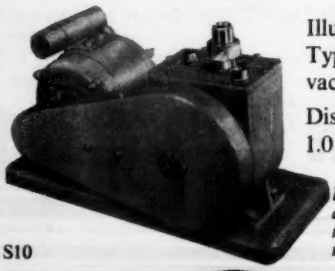

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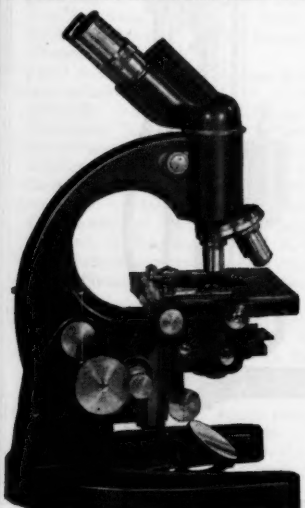

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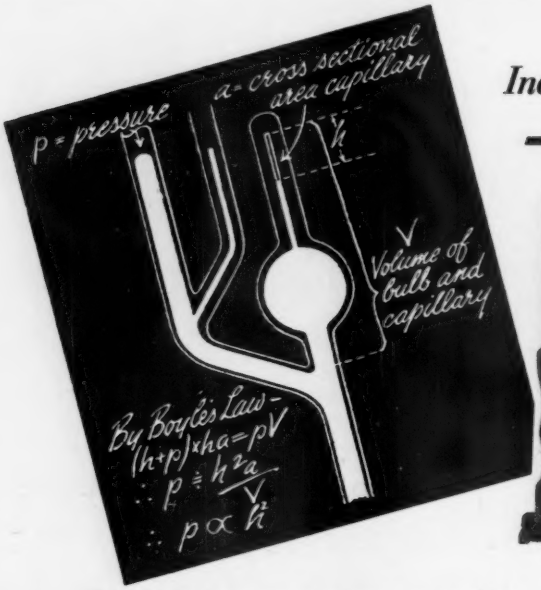

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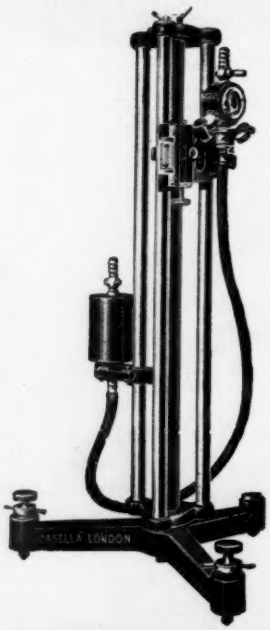

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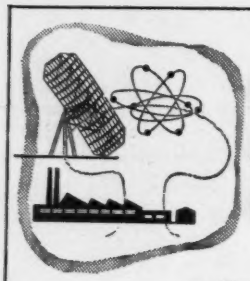

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REPRESENTATION OF SCIENCE AND TECHNOLOGY IN GOVERNMENT

FROM the point of view of science and technology in Britain, the most interesting of the changes in the Government formed by Mr. Harold Macmillan is the change in status of the Ministry of Fuel and Power. Under the title of Minister of Power, Sir Percy Mills, a former chairman of the National Research Development Corporation, who has been raised to the peerage, succeeds Mr. Aubrey Jones and has been given a seat in the Cabinet. The Paymaster-General, Mr. R. Maudling, will answer for the Ministry in the House of Commons, and the new Minister will be responsible for Government policy in relation to power resources generally. Besides assuming the existing functions of the Ministry of Fuel and Power for coal, gas, electricity and oil, he will be responsible for extending the use of nuclear energy as a source of industrial power, though the Lord President of the Council will retain responsibility for nuclear research. The Minister of Power will also take over from the President of the Board of Trade responsibilities for iron and steel.

Lord Mills's entry into the Cabinet will undoubtedly be welcomed in scientific and industrial circles. He will be responsible for a field in which decisions should turn mainly on technical rather than political considerations, and with his wide industrial and technical experience, he should strengthen the scientific representation at the highest level, while his experience with Government departments during the past twelve years may well avert the failure which in British political life has often attended this device to bring in an outsider of special ability to handle some vitally important task where great energy is required. That nuclear power may be thus characterized is not disputed, and Lord Mills may be expected to make without fresh delay the statement regarding the nuclear power programme which his predecessor promised after the Christmas recess. It may be taken for granted that Mr. Aubrey Jones, who becomes Minister of Supply, has completed the first phase and that, so far as Lord Mills is concerned, his major task will be to balance the requirements of the programme against those of other claimants on the limited capital resources of the country.

The implications of Lord Mills's appointment, however, go deeper and are better discussed after noting the other changes of direct scientific interest. Sir David Eccles leaves the Ministry of Education before the implementation of the plans he has announced for the expansion of technical and technological education has more than begun; but Lord Hailsham's recent speech in the House of Lords debate on automation is evidence that the programme is left in good hands and the confusion between technical and technological education may well be clarified. The Minister of Transport and Civil Aviation enters the Cabinet, and the announcement referring to this change and to the functions of the Minister of Power stated that these developments reflect "the importance attached to the expansion and development of the basic materials and services which are vital to the efficiency of British industry". Mr. C. I. Orr-Ewing, Parliamentary Under-Secretary to the Air Ministry, is the only member of the Government specifically qualified in science.

Before considering the merits or demerits of some training in science on the part of those holding high political office, the position in regard to the responsibility for scientific matters should be noted. Lord Salisbury, as Lord President of the Council, retains his responsibilities for the main supervision of the scientific research effort of Britain. The Agricultural and Medical Research Councils, as well as the Advisory Council on Scientific Policy, are responsible to him, as is also the Atomic Energy Authority; though it would appear that responsibility for the development of nuclear power, so far as that Authority is concerned, is now to be shared with the Minister of Power. Despite these responsibilities, however, there is so far no evidence that the Lord President is being provided with an appropriate departmental staff, and while the Paymaster-General will also answer questions relating to nuclear energy within the responsibility of the Lord President, the Parliamentary Secretary to the Ministry of Works continues to be the Lord President's spokesman in the House of Commons generally. Until at least the Lord President is provided with his own direct spokesman in the House of Commons in the form of a Parliamentary Secretary, the reality of the Government's appreciation of the importance of science in national life will remain suspect. The argument for a direct spokesman of science in the House of Commons is on all fours with that which demands that the Chancellor of the Exchequer should be in the House of Commons.

Possibly the need might be met temporarily if Mr. Maudling were made spokesman for the Lord President as well as for the Minister of Power. Mr. Maudling, it is true, has no seat in the Cabinet; but he has Ministerial status himself. Nevertheless, the objection would still remain that neither for the Lord President nor for the Minister of Power can he deal with Parliamentary questions, or explain and expound policy with the authority of inside knowledge. So far as the Minister of Power is concerned, the device may well forestall criticism and objections in the House of Commons; but it does not meet the much more fundamental objection regarding the interpretation of scientific or technical policy to Parliament.

The importance of this task of interpretation and exposition—when neither Parliament, the Government nor the Civil servants responsible for elaborating and working out the details of the policy for which the Government is responsible have in general the understanding of scientific and technical factors—is very far from being generally recognized. It is much more vital than the question whether the scientist or technologist should be found in the Cabinet. If a scientist possesses with his professional knowledge and skill the administrative and political gifts and

ambition, his scientific or technical training should certainly be no bar. What matters is that, collectively and individually, Ministers should be capable of understanding and assessing the value and significance of the scientific and technical factors in any problem on which they are called upon to formulate policy.

For all the lead that Lord Haldane gave to the belief that a scientific point of view could be of value in determining high policy, it is very far from being accepted to-day. It becomes, however, a matter of increasing public importance with every fresh development, such, for example, as the nuclear energy programme, if Britain's resources are to be wisely used and economic policy soundly based. Until the educational system ensures that school-leavers generally—and not solely the graduates in science and technology—have some understanding of what science is and how it works, and have learnt at least how and where to seek for information on scientific and technical problems with which they may be confronted, it matters greatly that Ministers carrying such great scientific and technical responsibilities as Lord Salisbury and Lord Mills should have within their Ministries those competent to speak to the House of Commons with inside knowledge and full scientific and technical understanding.

That is not to urge that a scientist or technologist as such should be appointed to particular Ministries. Other gifts are far more important than scientific and technical knowledge, though some scientific and technical knowledge may well in future become an essential qualification. Lord Mills's appointment does, however, raise afresh the problem of the place of the expert in Government, and how to recruit to high political office men possessing the requisite technical knowledge, administrative gifts and energy when their party political interests are slight. With the abolition of university representation, the independent member has disappeared from Parliament, and it is at least an open question whether the device adopted of bringing Lord Mills into the Government is a precedent that should be followed, except on very rare occasions.

Without, however, a general improvement in public education, we may well be forced in the meantime to rely on such devices if the problem of the relation of knowledge and power is to be solved. Indeed, Prof. H. Finer remarks in a contribution to the symposium "Science and Government" in the November 1956 issue of the *Bulletin of the Atomic Scientists Association* that Britain seems to have established an intelligent balance between the sovereign Parliament and the expert. That balance depends, however, on conditions which Prof. Finer indicates, and which are dynamic and changing, rather than static. If, for example, political parties cease to be responsibly minded, or to discipline their own members from the point of view of the public good as well as of party advantage, the balance may well be upset, quite as much as if Ministers or permanent officials become incapable of unravelling complex technical issues.

Prof. Finer, moreover, paid this tribute in comparison with the position in the United States, of which he was quite as critical as D. K. Price in his recent book, "Government and Science". Generally, indeed, Prof. Finer's criticism follows the same lines as that of Mr. Price; nor do the conclusions he formulates bear closely on British conditions, except in so far as he touches on considerations which may arise out of the necessity for security regulations. His contribution is one of two in the fifth part of the symposium on "Science and the Affairs of Man" commenced in the *Bulletin* last April in celebration of its tenth anniversary year.

The first contribution, by Mr. Walter Elliot, which draws largely on Sir Henry Tizard's Haldane Memorial Lecture, is more relevant, and Mr. Elliot endorses Sir Henry Tizard's verdict as to the lack of understanding of science which results from the fact that practically all Ministers and members of the administrative class of the Civil Service have had no scientific education. Mr. Elliot recognizes that we are far from solving the problem of the relation between science and government, and he gives whole-hearted support not merely to Sir Henry Tizard's remarks about encouraging the transfer to the administrative class of scientists with the requisite administrative ability and the formation of a central scientific staff, but also to the importance of educating the many in an understanding of the scientific outlook.

It has been apparent over recent years that neither the Defence Research Policy Committee nor the Advisory Council on Scientific Policy is exerting the influence that was hoped. The changes in the Government suggest that the time is ripe for a much deeper inquiry to see how Lord Haldane's ideas could be developed and some more effective arrangements made, both for the integration of the findings of science into public policy as required, and for securing adequate support for scientific work without external control. It is not so much that there is lack of sympathy, but a failure to understand the full implications, and particularly the need for accessory means and conditions if the full advantage of scientific and technical work is to be reaped. The failure to provide authoritative spokesmen for scientific ministries in the House of Commons or to implement, for example, the recommendations of the Advisory Council on Scientific Policy regarding the Science Centre and scientific libraries, indicates the lack of understanding and vision at the highest level which continues to handicap Britain's scientific and technical efforts. The Government might well note the remark of Mr. A. W. Tuke in his recent chairman's address to Barclays Bank when paying tribute to the Calder Hall achievement, that we must be prepared to pay our scientists properly and stop robbing them of all incentive by excessive taxation of their incomes. Such considerations are important; but they are ancillary to the task to which the changes in the Government primarily point, namely, fresh thinking about the adequacy of the structure of government, especially at Cabinet level, and the fundamental need of securing an efficient relation between knowledge and power, between the expert and the Minister and administration in the task of government.

THE LOGIC OF UNCERTAIN INFERENCE

Statistical Methods and Scientific Inference
By Sir Ronald A. Fisher. Pp. viii+175. (Edinburgh and London: Oliver and Boyd, Ltd., 1956.) 16*s*. net.

"THOSE who are not accustomed to original enquiry," wrote Francis Galton, "entertain a hatred and a horror of statistics." The implied suggestion that original inquiry necessitates statistics perhaps went a little further than he intended—though, to be sure, Galton seems to have had little use for anything that could not be expressed quantitatively. Certainly, however, it takes us further than many would be prepared to follow, even to-day. At the same time, there can be few who, having experienced the power of statistical treatment, would deny the value of the discipline it imposes not only on experiment, but also on the procedures and arguments by which experience is put to use in advancing scientific understanding. It faces us, in fact, with the need for making up our minds quite precisely about what we are doing, and how far we can go, when we seek to argue from the particular to the general. This lesson is hammered well home in Sir Ronald Fisher's latest book.

In his foreword, Fisher traces the development of the two great movements in statistics, towards the refining of methods used in the examination of data and towards the study of experimental design, and points out that from both have emerged, almost as by-products, specifically logical concepts which are essential to the formation of opinions applicable to the real world. These now call for exposition and consolidation in their own right. After a chapter on early attempts to give a rational account of the process of scientific inference, which deals at some length with Bayes's theorem and its limitations and with the concept of probability, he goes on to develop the notion of two levels of logical status lying between certain knowledge and total lack of it, related to, and springing from, the fiducial argument and mathematical likelihood, respectively. The fourth chapter deals with tests of significance, especially in relation to their differences from acceptance decisions. Then follows a discussion of probability and likelihood, and the book concludes with a consideration of the principles and criteria of estimation.

The emphasis throughout is on the problems of the scientist seeking to gain an understanding of natural phenomena from his observations and experiments. This is well exemplified by the discussion of tests of significance in relation to acceptance theory. At first glance, it might be expected that the level of significance, set in a test of any single body of data, should be reflected by the frequency which repetition of the experimental or observational procedure would be expected to produce results calling for the rejection of the null hypothesis when true. This is not, however, the case, as can be shown by consideration of the 2×2 contingency table. If significance is tested using the marginal totals as actually observed, the level of probability can be higher than that expected from repetition of the experiment, where the marginal totals may vary. The latter acceptance procedure might thus appear to offer a more powerful test of the hypothesis of independence. It achieves the lower probability, however, by admitting into the calculation sets of prospective observations having marginal totals incapable of providing any real test of the hypothesis, instead of confining itself to weighing the chances of critical observations in relation to those sets which alone afford a real test. Thus, as Fisher shows, the apparent value of the procedure is illusory, and he goes on to point out later that "as a matter of principle, the infrequency with which, in particular circumstances, decisive evidence is obtained, should not be confused with the force, or cogency, of such evidence"; and particularly, we might perhaps add, should not be allowed to encourage unjustifiable weight to be placed on the significance of the evidence just because it is not readily obtainable.

This is but one example of many that could have been chosen to illustrate the book's approach. A certain amount of mathematics is necessarily used; but the points at issue are always logical points, and the examples are chosen to illustrate the logical issues rather than their mathematical development. The objection to the indiscriminate use of Bayes's theorem is not that it is never applicable, but that logically its use makes certain demands of the situation—demands which are by no means always met. Similarly, the fiducial argument is possible only when certain requirements are fulfilled: in other situations the best we can achieve are conclusions having a different logical status, not always expressible in terms of probability but rather by mathematical likelihood. In this connexion, Fisher points out that if we ignore mathematical likelihood as a measure of rational belief it "would seem to leave [us] without valid resource in respect of a great many subjects in which rational inference is possible", adding, "the fact that stronger inferences may be desired, and are certainly possible in other cases, seems to be no reason for not attuning our minds towards understanding the information actually available"—a sentiment which surely must appeal to any experimental scientist.

"Statistical Methods and Statistical Inference" will not, one suspects, be easy reading even for many of the statisticians at whom, no doubt, it is primarily aimed. The less mathematically minded will find the going still harder. But persistence will be amply repaid by the deeper appreciation which is to be gained of those inductive processes which all experimental science must use, and which Fisher himself has done so much to analyse, clarify and expose for our better understanding.

K. MATHER

RESEARCH IN MECHANICS

Surveys in Mechanics
A Collection of Surveys of the present position of Research in some branches of Mechanics, written in Commemoration of the 70th Birthday of Geoffrey Ingram Taylor. Edited by G. K. Batchelor and R. M. Davies. (Cambridge Monographs on Mechanics and Applied Mathematics.) Pp. vi+475+16 plates. (Cambridge: At the University Press, 1956.) 50*s*. net.

IT must have been a labour of love for the collaborators in the present volume to prepare these tributes in commemoration of the seventieth birthday of Sir Geoffrey Taylor, and it was indeed a happy thought that every article in this volume should be a survey of the present position in some field of mechanics in which 'G. I. T.' has himself been

active at some time during the past fifty years. There is an all too short biographical note by Sir Richard Southwell and then the reader plunges into a number of extraordinarily interesting accounts of most varied fields of mathematical physics. There are papers on plasticity, on dislocations, on heat waves, rotating fluids, on drops and bubbles, on wave generation by wind, on sound waves, turbulent diffusion, atmospheric turbulence and the mechanics of sailing ships and yachts. Each one of these articles is in itself a little masterpiece of condensation and accuracy, and personal predilections must count for a great deal in the selection of any particular articles for special mention. To the present reviewer two articles seem especially remarkable—the magisterial account by Lighthill of viscosity effects in sound waves of finite amplitude and the concluding article by K. S. M. Davidson on the mechanics of sailing ships and yachts.

Lighthill's article of some hundred pages is especially valuable as giving a complete account of what is at present known about this difficult and important subject, and for the admirably clear and lucid summary which it provides of the physical mechanism of viscosity and other diffusion effects in gases.

Ken Davidson's article provides a fine example of the application of hydrodynamical principles to practical problems of sailing. There is a fine salty flavour in this all too brief article, which ranges easily over a great diversity of sailormen and ships from Columbus to Nelson, and from the catamaran to the clipper and the modern high-speed yacht.

G. Temple

NUCLEAR POWER

Calder Hall

The Story of Britain's First Atomic Power Station. By Kenneth Jay. Pp. vii+88+16 plates. (London: Methuen and Co., Ltd., 1956.) 5*s*. net.

Nuclear Energy in Industry

By J. G. Crowther. Pp. viii+168. (London: George Newnes, Ltd., 1956.) 17*s*. 6*d*. net.

"TO-DAY as power from Calder Hall begins to flow into the National Grid, all of us here know that we are present at the making of history," said the Queen at the opening of the Calder Hall Nuclear Power Station on October 17, 1956. "Calder Hall", written by the author of "Britain's Atomic Factories", describes the chain of thoughts and events that led up to this historic occasion. It traces from the early gropings and flashes of inspiration, the systematic study on paper and in the laboratory of the feasibility of various proposals, the emergence of an engineering design, and finally the construction with its concomitant development and research. The last chapter discusses the possibilities for the future of this type of plant and its place in the Government's ten-year programme for industrial atomic energy. The lucid exposition and fine illustrations are such that any intelligent layman can follow the arguments and appreciate the difficulties that have had to be overcome. Despite the excellence of Mr. Jay's book the reviewer feels that the subject is worthy of a more epic and less impersonal treatment, paying due tribute not only to the handful of brilliant engineers that conceived the project but also to the many hundreds of others who worked so single-mindedly to complete the plant on time and so establish this date in history.

In "Nuclear Energy in Industry" Mr. J. G. Crowther sets himself the wider task of examining the impact upon industry of developments in the nuclear engineering field. After an introductory chapter on the world's energy requirements and resources, there follows a chapter which attempts to explain just what nuclear energy is and how a nuclear chain reaction may be achieved. Further chapters describe various kinds of nuclear reactors and show how electrical power may be obtained from them. The concluding chapters are devoted to the application of radio-isotopes in industry, prospecting for uranium and thorium-bearing ores, the processing of these ores and the new metallurgical techniques that have been developed for the production of nuclear fuels and reactor components.

The major difficulty in a book of this kind is the linguistic barrier between the specialist and the non-specialist. It is essential that each new term or concept introduced should be adequately defined or explained. In this respect the book reviewed fails; for example, on p. 15 the definition of energy given is really that of power, on p. 26 the author speaks of a flux in terms of neutrons crossing each centimetre of core where square centimetre is correct, and on p. 31 he refers to a rating of "1,000 kilowatts of fissile fuel". Further criticism may also be made of the vast number of dimensions given in the chapter on reactors. Does the reader really want to know that there are 1,849 channels in BEPO or that the separation of the fuel elements in a "swimming pool reactor" is 0·117 in.? If the reader is prepared to obtain his grounding in the fundamentals of the subject from other sources, the book is a mine of information, containing as it does a hundred illustrations or figures, most of which can only be found in the 16-volume "Proceedings of the Geneva Conference on the Peaceful Uses of Atomic Energy".

W. K. Mansfield

ANALYTICAL TRANSFORMATIONS

Proprietà locali e globali di varietà e di trasformazioni differenziabili

By Prof. Beniamino Segre. Pp. 237. (Rome: Istituto Matematico dell'Università, 1956.) 2,400 lire.

DURING the past generation three widely different geometrical disciplines—algebraic geometry, differential geometry and topology—have undergone a process of interpenetration which has revealed unsuspected affinities between them and has accelerated progress in all three. The chief beneficiary so far has been algebraic geometry; to-day various results in this subject are most readily established by analytical or topological methods, while some of the deeper theorems can at present be proved only by pooling all available resources.

The present work, which is divided into six chapters, is based on lectures recently given by Prof. B. Segre in Rome and Pavia, and deals with a wide variety of overlapping topics. In general, the point of departure is the differentiable or, more restrictedly, the analytic manifold; the author shows how, by proceeding in various directions, it is both possible and profitable to link differential geometry on one hand with topology and on the other with algebraic geometry, in particular projective geometry. For

example, given an analytic point transformation between two manifolds, this may in general be approximated by a linear transformation, the projective invariants of which yield topological invariants. An important special case, one of the main themes of the book, is concerned with transformations of a manifold which possess a united point.

A second link with projective geometry is provided by the observation, due to C. Segre, that two curves with the same osculating space at a point possess a projective invariant which may be expressed as a cross-ratio. The author extends this notion to manifolds of any dimension, with special reference to the projective differential geometry of surfaces.

So far, the discussion has been mainly local, dealing with properties in the neighbourhood of a point. The next stage treats of differential properties in the large; beginning with an analytic curve on which is given an analytic correspondence, the author shows how this may be related to function theory by using the concept of residues, and thus obtains an interesting complement to the classical correspondence formula for an algebraic curve. He next derives a geometrical characterization of Abelian integrals attached to such a curve. These ideas are then connected with the equations, due to Jacobi and Reiss respectively, relating the differential elements of algebraic plane curves. In the last chapter the methods are extended to manifolds of higher dimension.

Nearly all this subject-matter now appears for the first time in book form; much of it is from the author's own researches and some has been specially written for the occasion. There are some useful historical notes to each chapter and more than one hundred references are given. The book, which is in cyclostyled typescript, is eminently legible, and fascinates by the continual interplay of apparently unrelated theories. Bound up with it is a brief account (in 44 pages) of some lectures on differential geometry by Prof. E. Čech.

L. Roth

ANATOMY OF A TECTIBRANCH GASTROPOD

The Anatomy and Histology of *Cylichna* (Gastropoda Tectibranchia)

By Henning Lemche. (Spolia Zoologica Musei Hauniensis, 16. Skrifter udgivet af Universitetets Zoologiske Museum, København, 16.) Pp. 278+46 plates. (København: E. Munksgaard, 1956.) 50 kronor.

THE section of Tectibranch Gastropods, sometimes called the Cephalaspidea, because of the shield-like flattening of the head tentacles, has received relatively little attention from the zoologist, probably as there are only few and small species in a handful of families, often restricted in geographical range. A monograph on the arctic species of the genus *Cylichna*, a member of the Scaphandridae, is therefore welcome. Dr. H. Lemche found, while engaged on the opisthobranch fauna of Iceland and Greenland, that not only were the species of *Cylichna* difficult to distinguish, but also the anatomy of the genus was "almost completely unknown". In this work, assisted financially by the Carlsberg Foundation, the author describes fully the anatomy and histology of *Cylichna cylindracea* Pennant 1777, comparing it with *C. alba* Brown 1827, *C. occulta* Mighels 1841 and its subspecies *densistriata* (Leche 1878), and *C. magna* Lemche 1941. The material used was obtained from the Kattegat, the Gullmarfjord on the Swedish west coast, and from the East Greenland Expedition's collections by Dr. G. Thorson during 1931–34.

The small size of the specimens is indicated by the shell measurements, which vary from 6·4 mm. long and 2·5 mm. broad in the smallest species to 17 mm. long and 7·5 mm. broad in the largest.

Cylichna lives in the *Venus* community on fine sand at a depth of 30–50 metres in the Kattegat and Skagerrak, burrowing into the substratum. All attempts to watch it feeding were unsuccessful, and most preserved specimens have an empty crop, but Dr. Lemche found a few specimens with food in the gut, and he infers that they feed by ciliary and shovelling action on microplankton, probably on small testaceous rhizopods. A ciliary current, assisted by mucous secretion, is also employed for moving the sand particles in burrowing, passing the grains over the cephalic shield, along the shell opening to the posterior, or beneath the foot and along the under side of the shell, the mucus preventing the sand from entering the pallial cavity. Thus, while burrowing, the animal is enclosed in a mucous cylinder. A funnel-shaped groove on each side of the head shield directs water over the pigmented organ of Hancock into the pallial cavity, whence it is forced out through the cloacal siphon on the right side. This is illustrated diagrammatically in Figs. 336–339 on Plate 37.

The columellar muscle is of interest in that, after leaving the umbilical region of the shell, it becomes U-shaped in the neck, then forms a hollow cylinder in the head, with dorso-lateral, lateral, ventro-lateral and medial portions. This Lemche interprets as corresponding to the dermo-muscular tube of Annelids. The sinistral portions of the columellar muscle are those directly concerned with attachment to the columella of the coiled shell and with withdrawal of the head into the shell, but the dextral portions are related to the upper side of the visceral sac, where in Prosobranchs the operculum would lie. In Prosobranchs the main portion of the columellar muscle is related to the shell and the operculum, whereas in *Cylichna* it runs forward to the head in the position of the retractor muscle of the velum of the larva. Lemche concludes that the columellar muscles in prosobranchs and opisthobranchs are not homologous. But is this conclusion warranted? He had probably not had the opportunity of reading D. R. Crofts's paper (*Proc. Zool. Soc. Lond.*, 105; 1955) on muscle morphogenesis in *Haliotis* and other prosobranchs when this was written. Miss Crofts traced the development of the pre-torsional larval muscles through torsion and the post-metamorphosis stage, and only an embryonic study could confirm the supposition that the muscles in *Cylichna*, and presumably in other opisthobranchs, are not homologous with those in prosobranchs, however plausible appears the condition in the adult.

Measurement of the gonad in numerous specimens shows that *Cylichna* is a perennial species, that it is probably two years old when spawning begins and that it lives three years at least. The first spawning occurs in June, sperm production after spawning being resumed in August. Young animals in their first year are purely, but not functionally, male. Then egg production begins while sperm formation ceases temporarily, the gonoduct being full of sperm.

It is not clear what activates the sperm. Cross-fertilization occurs, by the introduction of foreign sperm into a ciliated fertilization chamber, and, as usual in hermaphrodite molluscs, waste eggs and sperms are destroyed by phagocytosis. The fertile egg is enveloped in albumen inside its shell, then the winding gland adds gelatinous material and fixes the egg in position in an egg string held together by mucus from the nidamental and oviducal glands. The spawn after extrusion has not been found, but *Retusa*, an allied genus, has lumpy egg masses. Lemche says that *Cylichna* exhibits "simultaneous functional hermaphroditism without functional protandry".

The work is excellently produced and is illustrated by forty-six plates, with 361 figures; thirty-six plates are in half-tone, the remainder line blocks. In Plates 1–3 it is convenient having figures of the four species side by side for comparison. Plate 5 of the nervous system is not good; the figures 51–59 are too small, the outlines of the ganglia too faint and the wide-spaced guide lines to the reference letters are trying to the eye, so that one has to trace the figures to understand them. Fortunately, a clear coloured sketch of the nervous system in a line drawing is given on Plates 45 and **46**, to which the reader should refer. Both these drawings are reconstructions from serial sections.

It would have been helpful if a diagnosis of each of the four species had been summarized, or a key to them provided.

N. B. Eales

CATALYSIS

Catalysis

Edited by Prof. Paul H. Emmett. Vol. 4: Hydrocarbon Synthesis, Hydrogenation and Cyclization. Pp. vi+570. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1956.) 100*s*. net.

Catalytic Reactions

By V. I. Komarewski, C. H. Riesz and F. L. Morritz. Photochemical Reactions. By C. R. Masson, W. Albert Noyes, Jr., and V. Boekelheide. Electrolytic Reactions. By Sherlock Swann, Jr. (Technique of Organic Chemistry, Vol. 2.) Second completely revised and augmented edition. Pp. ix+543. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 11.50 dollars.

VOL. 4 of "Catalysis" contains, as its main feature, a series of four chapters, by R. B. Anderson and by L. J. E. Hofer, on various aspects of the Fischer–Tropsch hydrocarbon synthesis, in which long-chain aliphatic hydrocarbons are built up by the polymerizing hydrogenation of carbon monoxide. The reaction involved has considerable fundamental interest: first, from the point of view of the theory of the growth of the hydrocarbon chain; and secondly, on account of the complex catalysts used, from considerations of catalyst promotion. Too little is known, even now, of the mechanism of promoter action, although an appreciable recent contribution to this subject was made in Vol. 3 in a monograph by a group of chemists from the Dutch Staatsmijnen; and multi-component catalysts still have largely to be found empirically. The general treatment of the Fischer–Tropsch reaction in the present volume constitutes a reasonably comprehensive and well-documented review of the development of this industrially important process; and the interesting variation, known as isosynthesis, by means of which branched-chain, in place of normal, hydrocarbons are produced by varying the catalyst and by working at high pressures is also discussed in a chapter by E. M. Cohn.

The remaining sections, by M. Greyson, S. W. Weller and H. Steiner, are rather short and cover, respectively, the methanation of the carbon monoxide content of fuel gases, the liquid-phase hydrogenation of coal-oil pastes and, in a preliminary way, cyclization. Of these, the chapter on destructive hydrogenation in particular might well have been longer in order to provide a more adequate survey of berginization as an alternative to the Fischer–Tropsch synthetic approach to artificial hydrocarbon oils. This, however, is a minor criticism; and the volume under review certainly maintains the general high standard of the previous volumes in what will without doubt take its place as a major standard work on catalysis.

The second of the above books is part of a new edition of a well-known practical text-book dealing with laboratory techniques. There is a refreshing clarity in the monograph on the scope and experimental technique of the application of catalysis in organic chemistry which constitutes almost three-quarters of the volume; the contributors—V. I. Komarewski, C. H. Riesz and F. L. Morritz—are to be congratulated not only on their selection of good standard methods of catalyst preparation but also on their omission of much that is less material. In this, it is very evident that the selection has been based on practical experience, rather than on a survey of the now very large mass of available literature. This applies also to the review of apparatus for carrying out various types of catalytic reactions, high-pressure hydrogenation being treated in special detail. The article on photochemical reactions, by C. R. Masson, V. Boekelheide and W. A. Noyes, discusses the types of organic syntheses and other reactions which can usefully be carried out by the absorption of light quanta and reviews light sources and the general working methods involved. The final chapter, by S. Swann, covers electrolytic processes.

This issue of a second and enlarged edition of an already well-received text-book is an indication of the demand for works of this type.

E. B. Maxted

MUSEUM TECHNIQUES

The Conservation of Antiquities and Works of Art

Treatment, Repair, and Restoration. By Dr. H. J. Plenderleith. Pp. xvi+373+55 plates. (London: Oxford University Press, 1956.) 63*s*. net.

ALTHOUGH 'conservation' is traditionally quoted as the second function of a museum, those in charge of these institutions are often hard pressed to discover details of the correct methods to be adopted. Two books by the present author, "The Preservation of Antiquities" and "The Conservation of Prints, Drawings and Manuscripts", have been out of print for several years, and though very useful to curators, were scarcely sufficiently detailed in respect of the methods advised. The museum profession, therefore, is delighted that Dr. H. J. Plenderleith, of the Research Laboratory of the British Museum, with the practical experience of more than thirty years, has made the

opportunity to place at the disposal of his colleagues his unrivalled knowledge of the solution of so many conservation problems. It is little wonder, and indeed the Museums Association is honoured, that the book is now one of the official handbooks of that body.

The book opens with a stimulating chapter on the influence of environment and rightly stresses the fact that so often an object when subjected to new conditions of temperature and humidity suffers rapid and perhaps irretrievable damage. Dr. Plenderleith gives some useful facts concerning museum climate, and the limits of atmospheric conditions are defined as lying between 50 per cent and 65 per cent relative humidity at temperatures ranging from 60° to 75° F., that is, those to suit the comfort of visitors. Dr. Plenderleith then proceeds to deal with the various organic materials composing museum objects. These include animal and skin products, papyrus, parchment, paper, prints, drawings, manuscripts, textiles, wood, bone, ivory and easel paintings. In each case sufficient details are given for the reader to acquire a knowledge of the chemical and physical properties of the material. Methods of preservation are then discussed in detail, though the warning note is often sounded concerning the amateur craftsman who attempts to carry out a process without realizing the implications of each step. The next section of the book opens with a general introduction to metal objects and then discusses gold, electrum, silver, copper and its alloys, lead, tin, pewter, iron and steel on somewhat similar lines as the previous section dealt with organic materials. A final section on stone, ceramics and glass concludes this part of the book.

In each section there is a wealth of illustrative examples, and as Dr. Plenderleith has dealt with some of the most important archæological excavations during the past thirty years he is never in want for the appropriate object either for a description in the text or a half-tone or line illustration. Among other sources these are taken from the material found in Ur of the Chaldees, the Sutton Hoo ship burial, the Mildenhall treasure and the Walbrook Mithræum. The final part of the book includes thirteen appendixes of useful constants, strength of solutions, dangerous chemicals and other facts constantly needed by the museum conservator.

The well-known and meticulous work of Dr. Plenderleith forms a unique combination of scientific knowledge and a specialized form of craftsmanship united with a scholarly and intense devotion to the objects themselves. Throughout, he has tried to imbue the reader with his own rigid discipline and at the same time to warn him that certain complicated techniques are for the expert only, though it is important that those in charge of part of the national heritage should be familiar with the underlying principles of conservation. That the book can be recommended to all museum curators, librarians and archivists is an understatement, for no responsible individual in any of these professions dare work without this text-book constantly at hand. It is the most comprehensive work of its kind in any language, for it not only details in compact form old and well-established methods of treatment, repair and restoration, but also many new methods are here published for the first time. Our congratulations to Dr. Plenderleith are coupled with sincere thanks for such a monumental work which the publishers have been able to produce at a fairly reasonable price.

F. S. Wallis

THE BRITISH AND FRENCH CIVIL SERVICES

The Civil Service in Britain and France

Edited by Prof. William A. Robson. Pp. vii+191. (London: The Hogarth Press, 1956.) 21*s*. net.

In issuing in more permanent form nine essays which originally appeared in a special number of *The Political Quarterly* of October–December 1954, which commemorated the centenary of the Trevelyan–Northcote reforms, opportunity has been taken not merely to revise or expand some of the essays but also to include five new ones. One of these, by the Right Hon. A. Creech Jones on the Colonial Service, rectifies an outstanding omission in the original collection, and gives a clear and balanced account of both the work and problems of the Service, together with a number of constructive suggestions. Two further essays, that by Sir Thomas Padmore on "Civil Service Establishments and the Treasury" and that by Mr. Douglas Houghton on "Whitley Councils in the Civil Service", supplement Sir John Wood's essay on Treasury control of public expenditure. They outline the way Treasury control of the numbers and grading of Civil servants and of their conditions of service is exercised, and the manner in which the Whitley Councils have in practice succeeded, over the past thirty years or so, both in keeping the peace between the official and the staff sides of the Service, and in making some three-quarters of a million people happy in their work. In neither account is the difficulty of keeping a balance between central control and departmentalism minimized, but they indicate that in this respect the British Civil Service on the whole has been notably successful.

In the fourth of the new essays, that by Prof. André Bertrand on "The Recruitment and Training of Higher Civil Servants in the United Kingdom and France", it is suggested that whereas the French system requires to originate new techniques in recruitment to give more weight to the evaluation of the candidates as a whole with an emphasis on qualities other than the purely intellectual, we in Britain require to strike a new balance between a liberal education and the social services. Prof. Bertrand also believes that we should set up some form of professional training school for the young Civil servant. In the fifth essay, on "Bureaucracy and Democracy", Prof. W. A. Robson, while correcting some of the false notions of bureaucracy frequently fostered by those not anxious to help an improvement in the technique of government, argues that, if the spirit of democracy is to permeate the administrative process, the Civil Service must be completely integrated in the community. While in recruiting the administrative class the chief emphasis should be placed on administrative ability and high intellectual capacity, a strong effort should be made to ensure that neither this class nor the Foreign Service is too much dominated by those drawn from one section of the community. Prof. Robson again urges the importance of an effective and continuous system of communication between government departments and those sections of the public they serve or control and, lastly, he suggests that we should encourage widespread participation in the administrative process by those who are neither professional politicians nor Civil servants. For its constructive suggestions no less than for the penetrating discussion of some of the root problems in

modern government, this collection of essays well merits this more permanent form of presentation. They contain much to interest the scientist, although the place of the scientific or technical expert in government is discussed only in general terms by Mr. H. R. C. Greaves in his essay on the structure of the Civil Service. R. Brightman

THE TABULATION OF MATHEMATICAL FUNCTIONS

Tables of the Function arc sin z

By the Staff of the Computation Laboratory. (Annals of the Computation Laboratory of Harvard University, Vol. 40.) Pp. xxxviii+586. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1956.) 100*s*. net.

Spheroidal Wave Functions including Tables of Separation Constants and Coefficients

By J. A. Stratton, P. M. Morse, L. J. Chu, J. D. C. Little and F. J. Corbató. (Technology Press Books in Science and Engineering.) Pp. xiii + 613. (Cambridge, Mass.: Technology Press of the Massachusetts Institute of Technology; New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 100*s*. net.

THESE two books of tables illustrate an interesting contrast in the problems presented in tabulating a mathematical function, and in the methods of dealing with these problems. Both were computed on automatic computers, both come from Cambridge, Massachusetts, and both are substantial, but with this, resemblance practically ceases.

The first provides a definitive table of a standard mathematical function $f(z) = \sin^{-1} z$ or arc sin z over the complex plane of $z = x + iy$. By symmetries of the function, only positive values of x and y need be considered as tabular arguments. There is, however, a singularity at $z = 1$. The tables give six-decimal values of real and imaginary parts of $f(z)$ for intervals in x and y which are small near $z = 1$; in fact, $\delta x = \delta y = 0{\cdot}002$, while x and y extend over the intervals $0{\cdot}916 \leqslant x \leqslant 1{\cdot}090$, $0 \leqslant y \leqslant 0{\cdot}140$, respectively. The intervals are successively increased to $\delta x = \delta y = 5$, for which values the total extent of the table is $0 \leqslant x \leqslant 195$ with $125 \leqslant y \leqslant 475$, and $200 \leqslant x \leqslant 475$ with $0 \leqslant y \leqslant 350$. To aid interpolation, real and imaginary parts of $h\mathrm{d}f/\mathrm{d}z$ and $\frac{1}{2}h^2\mathrm{d}^2f/\mathrm{d}z^2$ are tabulated; in this $h = \delta x = \delta y$ is the tabular interval. The unorthodox use of δ for h in table headings is misleading and requires a word of warning; for example, $\delta f'(z)$ does *not* mean a difference, but $\delta \times \mathrm{d}f(z)/\mathrm{d}z$. The presentation and printing of the tabular material are otherwise excellent. An introduction describes the properties of the function $\sin^{-1} z$, and the details of the calculation and checking, and of interpolation into the tables. The writer has not tested the tables for accuracy, but the care taken by the Harvard Computation Laboratory and its experience in making mathematical tables are well known, and accuracy can be expected to be high, probably perfect. The tables were prepared on the Harvard Mark IV Calculator.

The second table should, perhaps, be regarded as, in a sense, experimental—though a highly developed and substantial experiment. The spheroidal wave-functions tabulated involve several parameters and depend on theory of relatively recent development. The former consideration rules out anything like a really complete tabulation (though an even more substantial volume of actual solutions is foreshadowed), and the latter may mean that the best form of tabulation has not yet been found. This appears to be true even of Mathieu functions, which involve a parameter fewer. The authors must be congratulated on a really substantial attempt to make the spheroidal wave-functions readily available to workers in this field. Two sets of tables are given—for prolate and oblate spheroidal wave-functions, respectively. The wave-functions themselves are not tabulated, but are given in the form of expansions in series of spherical Bessel functions $j_{n+m}(\xi) = (\pi/2\xi)^{\frac{1}{2}} J_{n+m+1/2}(\xi)$ in the case of radial functions J, which satisfy the differential equation that arises from Laplace's equation by separation of variables after transformation to spheroidal co-ordinates, namely,

$$\frac{\mathrm{d}}{\mathrm{d}\xi}\left[(\xi^2-1)\frac{\mathrm{d}J}{\mathrm{d}\xi}\right] - \left(A - h^2\xi^2 + \frac{m^2}{\xi^2-1}\right) J = 0 \qquad \text{(prolate)}$$

or

$$\frac{\mathrm{d}}{\mathrm{d}\xi}\left[(\xi^2+1)\frac{\mathrm{d}J}{\mathrm{d}\xi}\right] - \left(A - g^2\xi^2 - \frac{m^2}{\xi^2+1}\right) J = 0 \qquad \text{(oblate)}$$

or in series of associated Legendre functions $P^{m}_{m+n}(\eta)$ in the case of angular functions S, which satisfy the differential equation

$$\frac{\mathrm{d}}{\mathrm{d}\eta}\left[(1-\eta^2)\frac{\mathrm{d}S}{\mathrm{d}\eta}\right] + \left(A^2 - h^2\eta^2 - \frac{m^2}{1-\eta^2}\right) S = 0 \qquad \text{(prolate)}$$

or

$$\frac{\mathrm{d}}{\mathrm{d}\eta}\left[(1+\eta^2)\frac{\mathrm{d}S}{\mathrm{d}\eta}\right] - \left(A^2 - g^2\eta^2 - \frac{m^2}{1+\eta^2}\right) S = 0 \qquad \text{(oblate)}$$

In these, m (an integer) and A are 'separation constants'. The tables give coefficients in all four expansions for $m = 0(1)8$, $l = m(1)8$, and with h or $g = 0(0{\cdot}1)1(0{\cdot}2)8$. Seven-figure values are given for coefficients down to about 10^{-10} for radial functions, and down to about 10^{-18} or 10^{-20} for some angular functions. The separation-constants A are not given directly, but can be obtained from seven-figure values of t where

$$A = l(l+1) + h^2\left[\frac{2l(l+1) - 2m^2 - 1}{(2l-1)(2l+3)} + t\right]$$

The tables were produced on the Massachusetts Institute of Technology's computer, Whirlwind I, and have been reproduced quite well, though both format (with its too lavish use of space) and typed material reproduced are inferior to those of the Harvard volume; they are nevertheless adequate.

The introductory matter consists of a reprint of an article by Chu and Stratton from *J. Math. Phys.*, **20**, 259–309 (1941), and a rather too sketchy introduction to the tables by Little and Corbato. This is a valuable pioneer table. J. C. P. Miller

Proceedings of the C.E.R.N. Symposium on High Energy Accelerators and Pion Physics

Geneva, 11th–23rd June, 1956. Vol. 1: High Energy Accelerators. Pp. xiii+567. Vol. 2: Pion Physics. Pp. xii+443. (Geneva: C.E.R.N., Service d'Information, 1956.) 40 Swiss francs each volume.

THE 1956 Symposium of the European Organization for Nuclear Research has already been reported in *Nature* (178, 116; 1956). Vol. 1 of the Proceedings deals with high-energy accelerators, and Vol. 2 with some techniques and results of high-energy nuclear research. The early publication of these large volumes, each containing about eighty papers and summaries of the discussion, is a noteworthy achievement, particularly since the standard of production is excellent throughout. Many of the papers contain much more detail than could be covered in the spoken versions, because authors were asked to submit detailed texts before the symposium; these 'preprints' greatly aided discussion, and now, with corrections where necessary, form the basis of the Proceedings. With the inclusion of many papers by Soviet authors, Vol. 1 is the most comprehensive collection of papers on high-energy accelerators which has yet appeared; most of the information was previously either unobtainable or buried in a mass of project reports of many laboratories, and the degree of detail reported in many cases far exceeds what can be accepted nowadays in the journals. Consequently, Vol. 1 will be most valuable to accelerator specialists. Vol. 2 is not so all-embracing, by design of the organizers; save for an important contribution on anti-proton physics, it is restricted to the lower energy ranges. Moreover, the preparation of lengthy 'preprints' is less readily applicable to nuclear research than to studies of accelerators or techniques. Nevertheless, the same high quality of material and presentation is apparent, and at 40 Swiss francs per volume the Proceedings are a bargain. It is a matter for satisfaction that this highly successful symposium was organized by a young international institute, set up by the co-operative efforts of twelve nations.

T. G. PICKAVANCE

Atomic Structure and the Strength of Metals

An Account for the Nonscientist of Recent Researches aimed at understanding why Metals have their Characteristic Strength and Ductility. By Prof. N. F. Mott. (The Page-Barbour Lectures for 1956 at the University of Virginia.) Pp. vi + 64 + 13 plates. (London and New York: Pergamon Press, Ltd., 1956.) 15*s*. net; 2.75 dollars.

THE accepted way to write a popular book on science is to describe things obviously wonderful: stellar nebulæ, atomic nuclei, living cells, and the like. But this does not properly reflect the scientific attitude—the urge to understand the working of all things, large or small, near or far, domestic or cosmic. In this little book Prof. N. F. Mott has attempted to convey to the non-scientist some feeling for this scientific attitude by arousing his interest in all the intriguing, difficult and surprising questions that have to be faced when one really tries to explain such a familiar process as the bending and breaking of a piece of metal. Writing with great clarity and simplicity, he first discusses the crystal structures of metals, to understand how atoms are packed together, and then shows that the only way to understand how these atoms slip past each other, or pull apart, is to think of the crystal as a kind of 'space' in which there exists various kinds of 'particles'—dislocations, vacancies, impurity atoms—with properties as intricate and fascinating as those of ordinary space. The understanding of these particles not only leads to the explanation of the strength of metals; it also enables one to solve a whole range of other problems, from the mechanism of crystal growth to the development of the photographic image.

Anyone who is a scientist at heart could not fail to enjoy this book, irrespective of whether he has been trained in science or not. A. H. COTTRELL

Man, Culture, and Society

Edited by Dr. Harry L. Shapiro. Pp. xiii+380+13 plates. (London and New York: Oxford University Press, 1956.) 45*s*. net.

THIS book comprises sixteen chapters by leading experts in anthropology. Most of the authors are American, but three chapters are contributed by British and one by a French scholar. It is a pity that Dr. Shapiro, of the American Museum of Natural History, did not write the whole volume himself or at least that he could not have made do with one or two colleagues: collective works are dull at the best of times and never more so than when written at an elementary level; indeed, some chapters read as though they were written to redeem promises and few can have given their authors much pleasure to compose.

The topics range from the biological endowment of man—dealt with by the editor himself in the opening chapter—to his prehistoric past (Chapters 2–4), the nature and growth of his culture and various aspects of his social life, such as language and writing, religion, economics and social grouping. Of the archæological chapters, Prof. Cressman's on "Man in the New World", describing the prehistory and achievement of the pre-Columban Indians, will probably be read with greatest interest by English readers. Prof. Hoebel contributes a clear statement of the nature of culture, and there are interesting chapters on some of the factors in cultural change. Language and writing, subjects too often neglected by contemporary British anthropologists, are well treated by Prof. Harry Hoijer. Prof. Redfield brings the volume to an end with a trenchant essay on "How Human Society Works". The book might serve for the initial year of undergraduate courses in anthropology. J. G. D. CLARK

A Handbook for the Identification of Insects of Medical Importance

By Dr. John Smart. With Chapters on Fleas by Dr. Karl Jordan, and on Arachnids by R. J. Whittick. Third edition. Pp. xi+303+13 plates. (London: British Museum (Natural History), 1956.) 40*s*.

THE third edition of this work was issued in March 1956. It differs little from the second edition of 1948, being a photo-litho reprint of this. Bibliographical references have been brought up to date, however, and some additions and corrections made in the text and in an appendix on mosquitoes. One regrets the increased cost from £1 in 1948 to £2 for the third edition. Nevertheless, it still remains a worth-while purchase for those who wish or need within the limits of a single book, well illustrated and bound, and of convenient size, information on the systematics and distribution of arthropods of medical importance.

D. S. BERTRAM

BOSCOVICH AND PARTICLE THEORY

By L. L. WHYTE

At a time when the theory of the fundamental particles is in need of new methods it is unfortunate that there is little first-hand knowledge of the work of one of the most original of atomists. This article seeks to remedy the recent neglect of the role of Boscovich (1711 ?–1787) in the history of atomism and to correct a misinterpretation which may have a bearing on current problems. For Boscovich's method, properly understood, displays in its purest form a type of atomic theory which has not yet been exploited.

Boscovich's doctrine of point atomism[1] was a speculative mathematical theory developed at a time when few quantitative data, outside gravitation, were available. It was derived from the requirement that the discontinuity of action by impact must be reduced to some kind of continuous action at a distance. The theory combines Leibniz's metaphysics (point monads) and Newton's physics (action at a distance, repulsive and attractive).

Boscovich's "atoms" (better called primary particles, that is, those non-composite permanent particles the stable arrangements of which constitute atoms, molecules, and solid bodies—our nucleons roughly correspond to this) are all identical, being simple permanent (quasi-material) mathematical points remaining at finite separations so that a finite number is present in any physical system. These point particles display propensities to approach or recede from one another, that is, actions between pairs observable as relative accelerations, which vary in sign as well as magnitude with their distances. Every pair of particles has associated with it a scale-fixed field, alternately repulsive and attractive, which determines their interactions, single particles possessing no quantitative properties. One basic expression for the interactions is to account for all physical properties, for example, gravitation, collisions, cohesion, sound, rigid and flexible rods, crystals, fluids, changes of state, etc. Chemical differences are ascribed to the contrasted structures of composite systems.

These Boscovichian point-atoms were well known from 1770 onwards and directly or indirectly influenced the development of many branches of mathematical physics including current particle theory. Other features of the theory also proved fertile. For example, in 1907 J. J. Thomson[2] showed that under Boscovich's alternating repulsive and attractive field only certain central orbits are stable, thus preparing the way for Bohr's discrete orbits. But around 1920 awareness of Boscovich's importance faded and his work has since been neglected in most historical and other surveys. Moreover, no analysis has yet been made of the various features of Boscovich's method which were original. This will be briefly attempted here, both to demonstrate his importance and to clarify the points where he differs from Newton.

In 1758 Boscovich's method contained at least five novel features. For it was the first mathematical theory: (1) to employ finite numbers of *point* particles (it substituted a continuous range of density for the sharp dualism of matter and empty space, setting no upper limit to density, and predicting the penetration of bodies by high-speed particles confirmed 150 years later); (2) of *kinematic* atomism (see below); (3) eliminating from basic theory the scale-free similarity property of the Newtonian law, by substituting equilibrium radii determined by a scale-fixed field for the finite size of the Newtonian particle, Boscovich being the first to employ expressions involving natural lengths in basic laws[3]; (4) seeking to derive many effects from a single expression which reduces to Newton's law as $r \to \infty$, when certain terms vanish; and (5) which was essentially relational, indeed almost relativistic[4], giving the first analysis of space and time measurements in which the spatial and temporal relations of a system are in some degree affected by its state of motion relative to all other particles in the universe (a century before Mach). Moreover, the theory was presented as a hypothetico-deductive mathematical scheme "concerned with facts not causes", its validity to be judged by its elegance and fertility.

Boscovich's theory is best known for (1). (3), (4) and (5) are mainly of historical interest. But (2) is still important, as here Boscovich has been misunderstood, and his method awaits exploitation.

Boscovich's commentators, with the exception of his translator, J. M. Child, describe his atoms as "point centres of force", without qualification. Thus Maxwell, in his influential "Atom" article[5], says that Boscovich's atoms exert forces on one another, and leaves it at that. Not having a theory of dimensions at his disposal it was perhaps natural that Maxwell failed to observe that Boscovich's *vis* and *massa* did not mean what 'force' and 'mass' meant for Newton and all mechanical theories.

We may classify most physical theories as mechanical (that is, using three primary dimensional magnitudes: L, T, M), or kinematic (that is, using two primary magnitudes only: L, T, and deriving mass-ratios from some new space-time geometrical or kinematic principle), though some are of mixed type. Nearly all atomic theories (including quantum mechanics) are mechanical. Einstein's Special Theory (for example, when applied to electrons) is a mixed theory, deriving the variation of mass ratios with velocity from a kinematic principle. Einstein's General Theory is a kinematic macroscopic theory, deriving mass properties from space-time geometry. Parts of Eddington's and of Milne's speculative theories were kinematic. Thus twentieth-century physics displays a tendency, as yet only partly realized, to eliminate mass and rely on kinematics. But Boscovich's theory is still the only example of a pure kinematic atomic theory.

For Boscovich, though he used the term *massa*, did not employ 'mass' as a third primary magnitude. Child (see ref. 1, p. xiii) says, "Maxwell, in ascribing mass to a Boscovichian point of matter, seems to have been obsessed by a prejudice. . . . The mutual *vires* ascribed by Boscovich to his pair of points, are really accelerations, that is tendencies. . . . The Theory of Boscovich differs from that of Newton in being purely kinematical". For Newton 'mass' wa

the quantity of matter defined as density times volume. Boscovich discarded this and substituted dimensionless factors which could serve as 'mass ratios', but were merely the ratio of the numbers of point particles in two systems and could, in principle, be determined by counting. This was possible because all the primary particles were postulated as identical. The power of this approach is evident in the fact that the 'centre of gravity' of a physical system in internal equilibrium was determined for Boscovich by pure structural geometry, without dynamical considerations.

This kinematic method is easy to understand to-day, thanks to the work of Einstein, Eddington, Milne, and others, but it was so original that until 1922 the significance of Boscovich's transformation of Newtonian mechanics remained unrecognized. Indeed, it is only now, faced by the obscure mass spectrum of the 'fundamental' particles, that we can appreciate the difference between mechanical and kinematic theories, and realize that when the latter can be developed they possess a crucial advantage over the former. For mechanical theories, by treating mass as an independent magnitude, render it intractable to analysis, whereas in a pure kinematic theory all mass ratios must be treated as secondary factors derivable from some structural, geometrical or kinematic principle. From this point of view the demand for a theory of particle masses may usefully be interpreted as the demand for a pure geometrical or kinematic particle theory.

Thus a consideration of Boscovich's atomism in the light of twentieth-century physics directs attention to the possibility that the future theory of particles may have to be based on geometrical-kinematic rather than mechanical principles.

[1] Boscovich, Roger Joseph, "Theoria Philosophiæ Naturalis . . . (A Theory of Natural Philosophy, Reduced to a Single Law of the Forces existing in Nature)". Latin–English edition, translation by J. M. Child. (Open Court, Chicago, London, 1922.) First Latin edition, Vienna, 1758. Boscovich was born in Ragusa, worked mainly in Italy, and was prolific in many fields. The present paper is restricted to his atomism; a broader survey will be published elsewhere.

[2] Thomson, J. J., "Corpuscular Theory of Matter", 160 (1907).

[3] Whyte, L. L., *Ann. Sci.*, **10**, 20 (1954).

[4] Silberstein, L., directed attention to the neglect of Boscovich's "remarkably clear and radical ideas regarding the relativity of space, time and motion". See his "Theory of Relativity", 2nd edit., p. 38 (1924).

[5] "Encyclopædia Britannica", 9th edit. (1875).

WEED CONTROL

THE third British Weed Control Conference organized by the British Weed Control Council met in Blackpool during November 6–8, 1956, under the presidency of Sir James Scott Watson. More than four hundred delegates attended, of whom about forty came from overseas, including a delegation from the Soviet Union.

The subject-matter ranged over a wide field, from educational and usage problems to the mode of action of herbicides and the ecology and taxonomy of weed plants. In the earlier conferences the main need was for a meeting of those engaged in the technology of weed control so that the great practical developments that had taken place since the Second World War could be published and discussed, and those conferences were invaluable in serving this purpose. Now, however, it is apparent that the subject has reached a size and complexity that can scarcely be covered adequately in all its technological and scientific aspects in a single conference organized along the same lines. Detailed discussions at scientific level, for example, would certainly have been out of place in the present conference because only a minority of the delegates were engaged in any form of research. The conference did not adequately provide the much-needed opportunity for the research worker in this highly specialized subject to present and discuss his results and techniques. The need for specialized meetings to deal with the research aspects of the subject, as opposed to the technology of weed control, was emphasized by the secretary of the Agricultural Research Council, Sir William Slater.

"Weed Control: a Record of Striking Progress" was the title of the introductory paper by Sir John Russell, who pointed out that in primitive agricultural systems weeds had their uses, providing grazing for livestock; in fact, in neither Greek nor Latin is there a word for 'weed'. Sir John paid tribute to the important contribution which industry had made to the advancement of agriculture, particularly in the field of agricultural chemicals, and he suggested that the efficiency of the new herbicides had been an important factor in the dramatic rise in yield of cereals in Great Britain in recent years.

R. E. Slade (Essex) suggested that it was not enough to regard weed-killers solely as means of increasing the yield. They ought, in addition, to allow a greater freedom of cropping, enabling those crops to be grown which suit the soil, available equipment and labour, and changing economic conditions, rather than crops that are simply taking their turn in a rigid system of crop rotation.

As a result of a survey carried out by the statistical department at Rothamsted in co-operation with the National Agricultural Advisory Service (D. A. Boyd), it appears that MCPA is used on about 90 per cent of the acreage sprayed for weed control. This contrasts strongly with the position in North America, where 2 : 4-dichlorophenoxyacetic acid (2,4-D) has been the predominant herbicide used.

At the invitation of the British Weed Control Council, Dr. E. Åberg (Upsala, Sweden) and Dr. C. Frankton (Ottawa, Canada) reviewed the progress in weed control research and development in their own countries. Reviews of this type are of particular value in the field of weed control, in which the action of herbicides may vary according to local climatic and ecological conditions and related plant species may differ in their economic importance. In Sweden, for example, *Galium mollugo* is a serious weed, while in Britain the only important weed species of this genus is *G. aparine*. The former species has been found in Sweden to be susceptible to the herbicide 2 : 4 : 5-trichlorophenoxyacetic acid (2,4,5,-T), although the latter is resistant, an illustration of the specificity of this compound. Dr. Åberg directed attention to the phenoxythioacetic acids recently discussed by Burström *et al.* These compounds appear to be more phytotoxic than the corresponding phenoxyacetic derivatives at cell-level but their

overall effect is less, and it is suggested that this is due to slower translocation or more rapid breakdown. Possible differences in selectivity have yet to be investigated.

One of the main interests of Dr. Frankton is the taxonomy and ecology of weeds, and he stressed the need for cytotaxonomic studies as an aid to the correct identification of important species. He quoted the example of rosebay willow-herb (*Chamaenerion angustifolium*), which has a somatic chromosome number of 72 in Canada, although that of the native British species is 36. Both Dr. Frankton and Dr. Åberg directed attention to the remarkable fact that relatively little is known about the taxonomy, life-history and ecology of many of our most important weeds.

The reports on new herbicides were awaited with especial interest. H. Gysin and E. Knüsli (Geigy Co., Switzerland) discussed the chemistry and herbicidal properties of a completely new class of herbicides, the triazines. The most promising derivative is 2-chloro-4,6-*bis*(ethyl-amino)-s-triazine, an extremely phytotoxic compound. It has a very low solubility, making it of particular promise as a persistent total herbicide for uncultivated ground. It also has selective properties at very low dosages on certain crops, for example, maize. Other less active triazine compounds have given selective weed control in cotton, beans, peas, potatoes and grapes.

A development of particular interest to many British farmers was the introduction by G. B. Lush and E. L. Leafe (Boots Pure Drug Co.) of 4-chloro-2-methyl-phenoxypropionic acid for the control of cleavers (*Galium aparine*). This new herbicide means that an important weed, which previously could be controlled in cereals only by sulphuric acid or the substituted dinitrophenols, DNC and dinoseb, may now be killed by a plant growth-regulator which is not toxic to mammals and which a farmer can apply by a low-volume sprayer. This discovery re-emphasizes the empirical character of chemical weed control. For some years it has been known that 4-chloro-2-methyl phenoxypropionic acid has growth-regulating activity, but as the test plants used have apparently excluded cleavers, its potential value has not been appreciated until recently. It may well be that a re-examination of other rejected compounds on a new series of weeds could give equally happy results.

Outstanding among new experimental techniques was the variable dosage spraying equipment by G. S. Hartley, R. K. Pfeiffer and R. T. Brunskill (Fisons Pest Control, Ltd.), described in *Nature*, **176**, 472 (1955). This equipment is mounted on a vehicle and dilutes the spray in a logarithmic manner as it travels along. Portable small-scale equipment based on a similar principle and designed for experimental work in the field was demonstrated by J. D. Fryer (Agricultural Research Council, Oxford). The standard of experimental spraying equipment for herbicide research is undoubtedly improving in Britain, allowing greater precision of application. One of the limiting factors at present is the lack of uniformity of commercially available nozzles, individuals of a given size and pattern often giving variable performance both as regards throughput and distribution of the spray droplets (K. Holly, Agricultural Research Council, Oxford). A review of nozzle designs was given by A. Westerman (G. Bray and Co.), who stated that some standardization of nozzle performance was being considered by the British Standards Institution. W. E. Ripper (Fisons Pest Control, Ltd.) discussed an interesting new technique making the use of herbicides possible on susceptible crops. The seed drill is modified so that after placing the seed and only partial filling of the drill, a band of adsorbent material is sprayed before complete coverage with soil and spraying with weedkiller. In this way it has proved possible to use herbicidal concentrations of MCPA in kale and *iso*propyl-*n*-phenyl carbamate in cereals without crop damage.

Of particular interest in the section on dinitrophenols was a consideration of the factors affecting the susceptibility of peas to dinitro compounds (O. R. Dewey *et al.*, Fisons Pest Control, Ltd.). It was demonstrated how damage to the leaf cuticle by wind, dust and rain can result in injury to the crop following spraying with DNC or dinoseb, due to increased retention and penetration of the spray. These authors also showed that the presence of chemicals such as trichloroacetic acid in the soil in which the plants are growing increases the wettability and probably the permeability of pea leaves due to interference with wax formation and excretion. Certain weeds are similarly affected, annual nettle (*Urtica urens*) so much so that pre-treatment with trichloroacetic acid at more than 1·0 lb. per acre resulted in this weed being much more susceptible to DNC than the crop (peas) in which it was growing.

In his paper on the "Principles of Selective Phytotoxicity", Prof. G. E. Blackman (Oxford) stressed the complexity of the factors which can modify the action of weed-killers on plants. He showed how retention can vary with the physical properties of the spray and with the type of plant, and quoted examples from the work of the Agricultural Research Council Unit at Oxford to illustrate this and also the factors affecting penetration, transport and action at cell level. The importance of these fundamental aspects of weed control was also emphasized by the work of R. T. Brunskill (Fisons Pest Control, Ltd.), who had found that the relationship between surface tension, droplet size and retention on pea foliage was by no means simple. He showed that varying the droplet size alone can profoundly affect the phytotoxicity of a given concentration of dinoseb to peas, an observation that is borne out by practical experience in the field, but which is not as yet the subject of any practical recommendation.

While Dr. Frankton pointed out that surprisingly little interest has been taken in the biology of weeds, it is a hopeful sign that five papers on weed ecology were presented at the conference. They clearly demonstrated the importance of basic studies to the weed investigator in helping him to understand the plants he is attempting to destroy. The ecology of *Papaver* spp., *Rumex* spp. and *Allium vineale* was considered in four research reports, and in the fifth, J. L. Harper (Department of Agriculture, Oxford) discussed the evolution of weeds with reference to the development of resistance to herbicides. He quoted the case of *Erechtites hieracifolia* growing in sugar cane plantations in Hawaii, previously very susceptible to 2,4-D and now fairly resistant. In this connexion, the danger of merely checking weeds, or obtaining only a partial control, is obvious.

Considerable time was devoted to reviewing the important problem of wild oats (*Avena fatua* and *A. ludoviciana*), for which no really satisfactory method of control has yet been found. Trichloroacetic acid and *iso*propylphenyl carbamate have both given useful results when incorporated into the soil

before sowing peas or brassica crops, but it is clear that these herbicides can only be regarded as filling a gap until something more effective is found.

Another difficult problem in the damp climate of Britain is the control of perennial grasses such as *Agropyron repens* and *Agrostis gigantea*, and it was pleasing to hear in reports from J. O. Green and T. Evans (Grassland Research Institute, Hurley), J. G. Elliott (Agricultural Research Council, Oxford) and T. C. Breese and P. F. le Brocq (Plant Protection, Ltd.) that 2 : 2-dichloropropionic acid (dalapon) has given such promising results. Unlike trichloroacetic acid, dalapon is absorbed through the shoot as well as the root.

The biological activity and possible value as herbicides of the gamma phenoxybutyric acids has been given much attention during the two years following their introduction by R. L. Wain in 1953. The results of field investigations with 2-methyl-4-chlorophenoxybutyric acid (MCPB) and 2 : 4-dichlorophenoxybutyric acid (2,4-DB) were described in seventeen research reports, the majority of which dealt with the toxicity of these compounds to crop plants. These new herbicides are of particular agronomic interest because of their reduced toxicity to clovers compared with MCPA and 2,4-D, allowing the safe treatment of undersown and direct sown crops. They are also less toxic to cereals, and reports by several authors, including T. C. Breese (Plant Protection, Ltd.), J. G. Elliott (Agricultural Research Council, Oxford) and K. Carpenter (May and Baker, Ltd.) showed that MCPB can be applied to cereals without damage at any stage of development between emergence and shooting. This should allow treatment at the time most favourable for weed control, in contrast to treatment with MCPA or 2,4-D, which cannot safely be applied to wheat and barley until five or six leaves have developed on the main stem of the cereal plant. Unfortunately, the phenoxybutyric compounds have proved less toxic to many weeds than their corresponding acetic homologues. The comparative toxicity of the more important of these compounds to weeds was reported by J. D. Fryer and R. J. Chancellor (Agricultural Research Council, Oxford), who also outlined some of the difficulties that field investigators in this important aspect of herbicide evaluation are likely to encounter. Some of the factors influencing the relative toxicity of phenoxybutyric and phenoxyacetic compounds were discussed by K. Holly (Agricultural Research Council, Oxford). The criterion of toxicity is one important factor ; for example, the relative toxicity of MCPA and MCPB to *Brassica alba* was found to differ greatly when assessed by mortality, or by suppression of growth. The interval between treatment and assessment can also influence the acetic/butyric toxicity ratio, presumably because of varying rates of action. Stage of growth at the time of treatment, on the other hand, has not influenced the relative toxicity ratio in clovers, peas and *Papaver rhoeas*, but the resistance of *Sinapis alba* has been found to increase with age more rapidly to MCPB than to MCPA. Much remains to be learned about the scientific and practical aspects of the phenoxybutyric compounds ; but their evaluation during the past two years has already done much to emphasize the complexity of herbicide research and the need for team work between the academic and applied investigator, if new compounds such as these are to be brought as quickly as possible into efficient practical use for the benefit of crop production.

FIRE RESEARCH IN GREAT BRITAIN

By S. H. CLARKE, C.B.E.

NOVEMBER 26, 1956, saw the twenty-first anniversary of the opening in Britain of a Fire Testing Station by the Fire Offices' Committee (the central committee of the fire insurance companies), with what was then the most up-to-date equipment for full-scale testing of the fire-resistance of elements of building construction. The rapid developments in buildings during the early years of the century and the urgent need for precise information about their probable behaviour in fire made the provision of these facilities particularly opportune. It was fortunate, too, that the Station and its equipment were immediately made available to the Building Research Station of the Department of Scientific and Industrial Research. The results of the early experimental work were embodied in the well-known report on "Fire-grading of Buildings"[1] and were used extensively in the revision of the model bylaws of the Ministry of Housing and Local Government.

By coincidence, November also saw the tenth anniversary of the establishment of the Joint Fire Research Organization by the Department of Scientific and Industrial Research and the Fire Offices' Committee, acting as equal partners in sponsoring the application of science to a national problem. The Fire Testing Station became part of the new establishment.

The present fire research programme is much wider than that originally carried out at the Fire Testing Station, but investigations of the behaviour of buildings and their components in fire are still a major activity. In order to keep abreast of some of the problems that are set by modern developments, such as the effect of fire on prestressed concrete, or the effect of fire in one compartment of a large building designed so that full advantage is taken of the strength of every part of the structure, it has been necessary to enlarge the floor furnace. The new furnace, which is the largest and most up-to-date in the world, is illustrated in Fig. 1. It can accommodate specimen beams up to 24 ft. in length, and specimen floors of any size up to 24 ft. × 12 ft. ; it can also be used for combinations of walls and floors, or to study structures that are continuous across a wall.

In studying the behaviour of walls and other units in fire, use has been made in recent years of the analogy which exists between the flow of heat in a single or composite solid slab and the flow of electricity through a line consisting of series of resistors and capacitors, by building an electrical model. This model has been used to study the flow of heat in a reinforced concrete floor supported by a prestressed concrete beam when the lower surface is exposed to heat from a fire which develops according to a predetermined time–temperature relation. Besides eliminating the need for many preliminary large-scale tests, this apparatus is useful in helping to reduce the information obtained from large-scale fire tests to

Fig. 1. Specimen floor being placed in position in furnace

a form in which it can be used by architects and engineers for future designs.

The carrying out of large-scale fire-resistance tests is, of course, both costly and time-consuming. Unfortunately, in the present state of knowledge, it is not feasible to use model techniques of the kind that are available to the designers of aircraft and ships. Investigations are being conducted to provide basic information upon which such methods could be developed, and a new 'Burning Building' is being constructed in which it will be possible both to extend this research and to carry out experiments in which models will be used. The building will be 150 ft. long × 38 ft. high × 50 ft. wide. It will be possible by means of a sliding roof to provide adequate venting of the combustion products, and fans will make it possible to study the effect of wind velocities up to 30 mile/hr. across an experimental area of 10 sq. ft.

The hazard of loss by fire touches so many sides of the activities of a nation that it is the concern of a number of government departments, and the fire research programme is designed to cover the work necessary to carry out their statutory duties. The field is so wide and varied that operational research is necessary. Through the co-operation of the Home Office and local authorities, the fire brigades provide a report on every fire that they attend. Statistics compiled from these reports have been developed in such a way that they provide an index to the effect of certain types of building construction on safety from fire, and on the effectiveness of fire brigade cover.

Operational research has enabled some quantitative judgment to be made of the extent to which carelessness and ignorance contribute to the outbreak of fire; for there can be no doubt that these are the major causes. At the same time, there are indications that it is unlikely that they can be sufficiently reduced by education of the public, and that, particularly where valuable commodities are at risk, it will be necessary to resort to means of eliminating the human element by 'tailor-made' fire protection which may include attention to building design and construction, and automatic detection and extinction installations. Provision is being made in new laboratories that are under consideration for facilities to carry out research and testing in connexion with all kinds of extinguishing apparatus. Basic research is being undertaken on the mechanism of extinction with a number of extinguishing agents; this work is being carried out at the Fire Research Station, and supporting work is being arranged in various universities.

An important part of the work of the Station concerns the initiation and growth of fire, a field which must be closely studied in order to understand the causes and rapid initial development of many fires. Some of this work is undertaken to assist the Factory Department of the Ministry of Labour and National Service to advise on improved protection against the hazards of fire and explosion with flammable gases, vapours or dusts. Work on the latter subject is being carried out by the Safety in Mines Research Establishment, so that full advantage is taken of expert knowledge in this field. Other studies of ignition involve the use of a wide range of sources of radiant heat capable of producing intensities up to 55 W./cm.^{2}. Experiments range from the exposure of small samples to these high intensities, to the examination of assemblies of protective clothing under radiation of the intensities possible when fighting severe fires (see Fig. 2).

Fig. 2. Testing protective clothing assembly under radiant heat

As with all the establishments of the Department of Scientific and Industrial Research, a large proportion of the time has to be devoted to answering inquiries and carrying out *ad hoc* investigations associated with them, and representatives of the Station sit on some forty-five committees of the British Standards Institution and other bodies.

At the present time the bulk of the work of the Station is being carried out in temporary laboratories, which it is hoped to replace by permanent buildings in the near future. It may be recalled in this connexion that it was announced last year that the Department of Scientific and Industrial Research and Fire Offices' Committee had agreed that new buildings and equipment should be provided at a cost of up to £365,000.

[1] Ministry of Works Post-War Building Studies No. 20. (H.M. Stationery Office, 1946.)

OBITUARIES

Mr. W. N. Edwards

WILFRED NORMAN EDWARDS, formerly keeper of the Department of Geology in the British Museum (Natural History), died suddenly on December 17 at the age of sixty-six. He was the second of three brothers, all of whom obtained distinction in a branch of natural science: the eldest, Fred, as an entomologist; the youngest, Donald, as an astronomer. Wilfred was educated with his two brothers at the Cambridge and County School, which at this time produced an outstanding group of naturalists, four of the boys, including the two elder Edwards, later joining the scientific staff of the British Museum (Natural History). Edwards gained a scholarship to Christ's College, and while at Cambridge came under the influence of the late Sir Albert Seward, an influence which determined his career as a palæobotanist.

After graduation, he successfully competed for a post on the scientific staff of the British Museum (Natural History) and joined the Department of Geology in 1913. The rather austere atmosphere then prevailing in the Museum seems to have weighed heavily on the young man, and he welcomed the break afforded by military service in the First World War. He served with the R.A.M.C. in the Balkans, and his experiences there certainly gave him a taste for travel in those parts, which later he fully indulged. On returning to the Museum after the War, Edwards, who was the first palæobotanist to be appointed to the staff, set about putting in order the gigantic but hitherto neglected collection of fossil plants, a task which he carried out admirably, for it was in curatorial rather than in research work that he excelled. Indeed, scientific research never seems to have been his major interest, although he was the author of more than forty publications—most of them brief—covering a wide range of palæobotanical subjects from all geological periods and notable for their painstaking accuracy. In later years more general topics, especially the historical side of palæontology, engaged his attention and he wrote an excellent little book as a guide to a special exhibit in the Department on the early history of palæontology. He was awarded the Lyell Fund by the Geological Society in 1933, and the Lyell Medal in 1955, in which year he was president of Section C (Geology) of the British Association.

In 1931 Edwards became deputy keeper of the Department, and thereafter administrative duties claimed much of his time. Late in 1938 he succeeded Dr. W. D. Lang as keeper. It was a frustrating time in which to succeed to office; instead of being able to put into practice his plans, especially for the development of the exhibition galleries, the whole of his attention was absorbed in arranging for the evacuation of the principal part of the collections and for the protection of the remainder. That so little of importance was lost, in spite of the extensive damage done to the building, was in no small measure due to his untiring efforts. The War ended, Edwards threw himself whole-heartedly into the work of reconstruction, and some of the most successful new exhibits, such as that in the Succession of Life Gallery, are due to his inspiration. Further, during the last years of his keepership he was responsible for the Department's new series of explanatory booklets or guides, which have become 'best-sellers', and did much to foster the production of a number of scientific publications, including the Geological Series of the Museum *Bulletin*. As an editor of scientific matter he was outstanding, and any publications for which he was responsible were excellent in format and quality.

Although little inclined to committee work, he served during the War as secretary of the Geological Society, and afterwards as a vice-president.

Kindly, and to his junior staff even indulgent, Edwards had on occasion a sharp tongue in controversy. But his criticisms were never pointless, and his most caustic humour was usually accepted with good grace as the price of worth-while advice. Edwards was essentially an individualist, and his dislike of the formal and orthodox was shown in many ways, not least perhaps in his strong agnosticism. By nature rather solitary, he admitted few to intimate friendship. One of his closest friends was the late W. B. Honey, keeper of ceramics at the Victoria and Albert Museum. Their association reflected, like the life-long interest in folk-dancing, his strong leaning towards the arts and crafts, in which he was given to experimenting in his own Department. His satisfaction in the results was often proportional to the surprise of his more conventional colleagues.

Edwards was very much a 'character', and his loss will be deeply felt for, in spite of his reserve, he was held in esteem and affection by his staff. He leaves a widow and a son.

E. I. WHITE

Prof. Methodi Popoff

IT has been ascertained that Methodi Popoff, Bulgaria's foremost biologist, has died within recent years. As a son of a successful physician, he had his early training at the University of Sofia. Later, the king, Czar Ferdinand, himself an enthusiastic student

of the Lepidoptera, sent him to Munich (about 1904) to finish his training in Richard Hertwig's institute. Here he took his doctorate with a thesis on the cytology of the prosobranch *Paludina*. His great ability and fine personality secured for him an assistantship and later 'habilitation' as *Privatdozent* in the University of Munich, a rare honour for a foreigner. During the following years he worked mostly on the physiology of growth and reproduction in *Paramecium*, inspired by Hertwig's ideas on the meaning of the nucleo-plasmic ratio. Some of this work, published in a series of elaborate papers, has become classic, and essential conclusions have only recently been confirmed in cell-physiological work. This work was interrupted by the Balkan wars. He returned to Bulgaria and became soon the senior medical officer in the army and did outstanding work for his country in very trying situations.

After the war Popoff was appointed professor of zoology in the University of Sofia. He served also as rector of the University and played an important part in the scientific life of Bulgaria. His research work dealt mainly with problems of the chemical stimulation of growth, on which he published extensively in an era before the discovery of auxins and growth hormones. At this time he was attracted to politics as a friend of the young Czar Boris, who sent him as ambassador to Berlin after the First World War, a position which he filled until the advent of the Nazis. In his modest legation he fixed up a small laboratory and every morning from 4 a.m. until breakfast—he never slept more than four hours—he was zoologist and worked on growth problems. For the rest of the day he was diplomat, and a very good one, due to his quiet but very able personality and his unusual charm. His legation became a centre of social life, where one could always meet the leaders of science and art in addition to the figures of political life. He was helped in this role by his German wife and by his linguistic ability (German, French, English, Turkish, Russian, Greek, Serbian).

In the early thirties Popoff fell out with the changed policies in Bulgaria and was recalled. When the King joined the Nazis he broke with him, and his courageous stand saved him later when Bolshevism took over. Before the Second World War he had been given a research institute in Sofia, where, with his usual energy, he started work in genetics (a few papers on *Drosophila* were published). After the revolution he was allowed to work there for some time and was treated rather respectfully. Then the iron curtain went down and nothing more was heard of him. The few of us left who knew him well remember him affectionately as a fine scholar and idealist, a man of character and a charming friend.

Richard Goldschmidt

NEWS and VIEWS

Electrical Research Association : Dr. H. G. Taylor

The appointment is announced of Dr. H. G. Taylor to the office of director of the British Electrical and Allied Industries Research Association in succession to the late Dr. Stanley Whitehead. For the past nine years, Dr. Taylor has served as director of another research organization, the British Welding Research Association. Dr. Taylor graduated in the Faculty of Engineering in the University of London in 1926, and in the following year was awarded the diploma of the Imperial College. Following a College apprenticeship with the Metropolitan-Vickers Electrical Co., Ltd., he joined the scientific staff of the Electrical Research Association, where for fully eight years he was engaged in investigations concerned largely with problems of safety, earthing, and earth currents in electrical systems. For his published work in this field the degree of D.Sc. (Engineering) was conferred on him by the University of London in 1940. During 1938–43 Dr. Taylor occupied the post of electrical engineer to the Copper Development Association, where he was concerned with problems in the application of copper and its alloys in the electrical industry. He joined in 1943 the Philips organization, in which he was responsible for development work in industrial electronics and in electric welding. As director of the British Welding Research Association Dr. Taylor has had a wide experience of the administration of a research association serving a rapidly developing industry. He rejoins the Electrical Research Association at a time when that body has entered upon a new phase of development in the laboratories recently built at Leatherhead.

British Agricultural and Food Attaché : Mr. M. Whalley Taylor, M.B.E.

Mr. M. Whalley Taylor, chief poultry advisory officer for the West Midland province of the National Agricultural Advisory Service, has been appointed agricultural and food attaché to H.M. Ambassadors at Copenhagen and the Hague. He will also hold a watching brief on technical agricultural developments and food trade trends in Western Germany. Mr. Whalley Taylor is forty-six. He was educated at Queen Elizabeth's Grammar School, Blackburn, and at Emmanuel College, Cambridge, where he took a B.A.(Agric.) degree in 1932 and an M.A. degree in 1936. During 1932–40 he farmed on his own account, after which he was appointed senior biology master at the Royal Grammar School, Clitheroe. During 1943–46 he was technical adviser and director of the experimental research farm for the Poultry Association of Great Britain. In 1946, Mr. Whalley Taylor was appointed to the staff of the Ministry of Agriculture and Fisheries as a county poultry advisory officer in the National Agricultural Advisory Service. He served as deputy agricultural attaché at the British Embassy in Washington during 1949–53. During this period he was promoted, and, on his return to England, was appointed chief poultry advisory officer for the West Midland province, in which post he has served until his recent appointment. He was made M.B.E. in 1954.

The Rockefeller Institute, New York

Prof. Edward L. Tatum has been appointed a member of the Rockefeller Institute, New York. Prof. Tatum, who has been professor of biochemistry

and head of the Department at Stanford University since 1948, assumed his post at the Rockefeller Institute on January 1. His field of research is the study of the genetics and metabolism of bacteria, yeast and moulds. He is attempting to arrive at a clear understanding, at the molecular level, of how genes determine the characteristics of living organisms. He was born in Boulder, Colorado, the son of a professor of pharmacology. After receiving the A.B., M.S. and Ph.D. degrees from the University of Wisconsin, he studied at Utrecht, Holland, as a General Education Board Fellow in bacteriological chemistry. He was professor of microbiology at Yale University during 1945–48. He is a member of the National Academy of Sciences, the National Science Board of the National Science Foundation and a member of the Research Advisory Committees both of the National Foundation for Infantile Paralysis and the American Cancer Society. He is a member of the editorial board of the *Journal of Biological Chemistry*.

Co-ordination of Government Scientific and Technical Research

THE leading article in this issue of *Nature* (p. 275) discusses the official representation of science and technology in Britain. A related question was put in the House of Commons by Dr. B. Stross, regarding the co-ordination of technological research in Britain, which referred to doubts expressed in scientific circles as to the adequacy of the existing organization. The Prime Minister replied on January 31, and said that an immense complex of research, undertaken by Government departments and Government-aided research organizations, is co-ordinated through the interaction of the research councils, advisory committees and research boards which control or advise on research programmes, and by extensive contacts between scientists and technologists working on related projects. In the civilian field, Government scientific policy comes generally within the responsibilities of the Lord President of the Council, who is advised by the Advisory Council on Scientific Policy. The Minister of Defence has similar responsibilities in the field of defence. The Atomic Energy Authority will remain the responsibility of the Lord President; but the practical development and implementation of research done by the Authority will be the responsibility of the Minister of Power. At all times, the Prime Minister added, the co-ordination of research is being kept under review, and he is prepared to consider any steps likely to improve the situation.

Higher Technological Education in the U.S.S.R.

AT a meeting of the Parliamentary and Scientific Committee on December 18, a discussion on the training and utilization of scientists and technologists in the Soviet Union was opened by Mr. W. K. Brasher, secretary of the Institution of Electrical Engineers, and Mr. H. E. Dance, of the Ministry of Education, to which contributions were made by other members of a team which had recently visited the U.S.S.R. Mr. Brasher said that their observations and figures for graduate technologists given by the Minister of Higher Education suggested that extension of a curve based on De Witt's figures would not be far wrong. Allowing for part-time students, the output of graduates or diplomates from technical institutes in 1956 would be about 60,000, and they were told that it was intended to stabilize the full-time entry at a little more than 90,000, with a total part-time entry of 150,000 by 1960. The present output in relation to population is three times higher than in Britain and twice that for the United States, but the standards differ. The present output of 142,000 technicians is an increase of 50 per cent in five years and expansion is expected to continue at this rate. The optimum ratio of technicians to technologists is put at about four to one. As regards quality, we in Britain are taking some six to twelve months longer to produce a man with, however, a much broader base to suit our needs and with a far greater practical knowledge of several engineering principles. The team concluded that to meet the needs of the two countries the standards are about right. Mr. H. E. Dance referred to the respect accorded to engineering in Russia and to the high proportion of women—as much as 50 per cent in most engineering faculties. The thirty-three universities were not concerned with engineering or technology, which was left to the higher technical institutes, of which about 180 were concerned with general technology and 136 with engineering. Mr. Dance was impressed with the high degree of co-operation between industry and the higher educational establishments in the Soviet Union.

Higher Technological Education in the British Caribbean

IN reply to a recent question in the House of Commons which was circulated in the Official Report, the Under-Secretary of State for the Colonies, Mr. J. Profumo, said that, after consultation with the British Caribbean Governments, a mission had been appointed "to consider proposed developments in the field of higher technical and technological education in the British Caribbean in relation to present and future needs; and in the light of probable financial resources to make recommendations". The chairman is Mr. G. S. V. Petter, educational adviser to the Comptroller for Development and Welfare in the West Indies, and the other members of the Mission, which is now in the Caribbean, are Dr. F. J. Harlow and Prof. J. A. L. Matheson. The United Kingdom Government at present contributes annually £47,000 to the Imperial College of Tropical Agriculture, Trinidad, and is to contribute up to £65,000 towards a new student hostel and an animal nutrition unit, and further grants are also made for research. Besides the services provided for the Commonwealth as a whole, the College provides facilities for undergraduate students in agriculture which are particularly valuable to the Caribbean. A capital grant of £10,000 has been made for the Sub-Department of Chemical Technology in the University College of the West Indies. The main task of the mission is to make recommendations on the development of other facilities for higher technical education in the area. The Governments of Barbados, British Honduras and Jamaica employ officers from Britain in charge of their institutes of technical education and in some of the higher teaching posts, and there is a vacancy in British Guiana for a principal of the technical institute.

Nuffield Foundation Biological Scholarships and Bursaries

THE Nuffield Foundation is continuing to offer annually a small number of scholarships and bursaries

to selected graduates in physics, chemistry, mathematics or engineering who have had no training in a biological subject, so that they may receive such training in biology as will enable them in due course to undertake research and teaching in the biological sciences in the United Kingdom. This scheme was introduced as an experiment a few years ago in an effort to attract into teaching and research in biology persons holding a degree in the natural sciences. The trustees hope not only to remedy in a small way the shortage of biologists, but also to bring to bear on biological problems the technical knowledge of those trained in the more exact disciplines of the natural sciences. The scholarships and bursaries are open to persons of either sex—usually between the ages of twenty-two and thirty-five—who hold a degree in physics, chemistry, mathematics or engineering of a university in the United Kingdom.

The scholarships are the senior awards: they are intended for persons who have already undertaken some postgraduate research in the subject in which they graduated. The bursaries are intended to enable those who have recently graduated to undergo a course of training in biological subjects. A full honours degree course in biology may be taken. Normally the value of a scholarship will be £500–£600 a year (plus fees). If a scholar should be required to spend part of his period of study abroad or to travel to Britain in connexion with his work, travelling expenses will also be paid. The value of a bursary will be £350 a year (plus fees). Marriage and family allowances will also be made. Successful applicants will be required to carry out a programme of work and training at institutions approved by the Foundation. Other work, paid or unpaid, may not be undertaken without the permission of the Foundation. Applications must be received by April 1 annually, on forms obtainable from the Director of the Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1.

Platinum Metals Review

In order to provide users of the platinum metals with information regarding their properties and industrial applications, Messrs. Johnson, Matthey and Co., Ltd. (Hatton Garden, London, E.C.1), have published the first part of a new quarterly journal *Platinum Metals Review*. The first issue contains an account of platinum mining at the Rustenburg Platinum Mines in the Transvaal; a paper on the use of platinum metals for bursting disks in the protection of pressure vessels used for chemical processes; one on electro-deposited rhodium in co-axial radiofrequency circuits; and details of a thermocouple suitable for high-temperature measurements, the elements of which consist of platinum alloyed with 5 per cent and 20 per cent of rhodium respectively. This couple can be used continuously at temperatures up to about 1,700° C., while for a single determination the limit is set by the melting point of the 5 per cent alloy, approximately 1,825° C. A large number of abstracts and three short notes on the creep properties of platinum metals and alloys and their use in catalysis and in cathodic protection complete an informative publication which should be of interest to a wide range of readers.

Mesolithic Culture in Japan

An article on "Some Stone Tools of Early Hoabinhian Type from Central Japan", by Dr. John Maringer, appears in *Man* of January 1957. It is not so easy to obtain any reliable information on the stone industries of Japan. Dr. Maringer's article, therefore, with its full-page illustration, is very welcome. The Hoabinhian is the name given to a mesolithic culture of south-eastern Asia, and the new pre-Jômon stone age industry in Japan resembles those on the mainland of early Hoabinhian date. There are many problems of a geological nature as regards Japanese pre-Neolithic cultures: it is not easy to see, for example, how contact could have occurred with the mainland after the destruction of the land bridges that may have existed during early and middle pleistocene times. The new finds have been made by Mr. T. Aizawa near the city of Isezaki in Gumma Prefecture. There are pebble tools, hammerstones, cores, flakes and flake tools, blades and blade tools. The materials used include grey shale, andesite, blackish chert, etc. There was a definite stratigraphy noted and the finds come from a considerable depth below the surface. Dr. Maringer makes a series of comparisons with industries from sites around Hoabinh and elsewhere which have yielded Hoabinhian industries.

The Forest Seed Directory

The Food and Agriculture Organization has now issued the 1956 edition of the Forest Seed Directory in English, French and Italian (London: H.M.S.O.). The introduction of economically productive exotics has become part of the forestry business in many countries. Since the growth of this branch of forestry the difficulties have been, first, to know how to obtain the seed required; secondly, to be assured of its authenticity from the area in which it grows at its best; and thirdly, to know how the climate of this habitat differs from that to which it is to be imported. Much is necessarily still left to the importer, but the Directory gives him very great assistance. The following information was requested from all member governments: "(1) Seed list of species, by scientific names, available for exchange or sale by governmental agencies; (2) seed list of species, by scientific names, available for exchange or sale by *all* commercial dealers, with their addresses, in the individual, indicating with an asterisk those dealers who were willing to supply, on request of the purchaser, the Certificates of Quality and Origin as adopted by the Conference of F.A.O. of 1951". A number of governments reported no change. Others revised their seed lists and added a list of commercial dealers, but only a few added the quality and origin certificates. The Directory is an excellent handbook for all wishing to know about forest tree seeds. It will not in future be issued annually, but only when a revision becomes necessary.

Eclipse of the Sun on October 2, 1959

A paper which provides very useful information regarding the total eclipse of the Sun on October 2, 1959, has been prepared by José M. Torroja and published by the Madrid Astronomical Observatory (Pub. No. 2, Comisión Nacional de Astronomía: "Datos para la Observacion del Eclipse de Sol del 2 de Octubre de 1959, en las Islas Canarias y Africa Occidental Española"). The data are restricted to the Canary Islands and Spanish territory in West Africa, and five figures and maps show the zone of totality and supply all necessary data for observers. Tables of meteorological conditions, cloudiness, rain-

fall, insolation, temperature, etc., are given for four of the islands and also for the meteorological observatories at Sidi Ifni and Cabo Jubi in Spanish West Africa. Figures and maps show the zones of totality for different places, and the four maps reproduce, on the scale of 1 : 500,000, the zones referred to in the text. This publication will be invaluable to all who contemplate observing the eclipse from the places mentioned in the text.

Standard X-Ray Diffraction Powder Patterns

THE sixth in the series of "Standard X-ray Diffraction Powder Patterns", prepared by the National Bureau of Standards, Washington, D.C., has recently been published as Circular 539 (pp. 62; 1956. 40 cents); in it are presented data for forty-four inorganic substances. Twenty-three of the patterns are to replace thirty-three already represented in the card file of the American Society of Testing Materials, and twenty-one are for compounds not previously represented. The card file serves as a system for the identification of unknown crystalline materials by matching spacing and intensity measurements. A comparison is made of all powder diffraction data available for each of the substances reported. The patterns were made with a Geiger-counter X-ray diffractometer, using samples of high purity. The *d*-values were assigned Miller indices determined by comparison with calculated interplanar spacings and from space group considerations. The densities and lattice constants were calculated, and the refractive indices were measured whenever possible. The Circular includes a cumulative index to Vols. 1–5; but further work in the programme is in progress and the index is not therefore necessarily the concluding index in the series.

British Glaciological Society

THE following officers and Committee of the British Glaciological Society have recently been elected: *President*, G. Seligman; *Vice-Presidents*, W. V. Lewis, K. S. Sandford and Sir James Wordie; *Hon. Treasurer*, G. C. L. Bertram; *Secretary*, Mrs. H. Richardson; *Committee members*, R. J. Adie, P. D. Baird, J. W. Glen, S. E. Hollingworth, J. F. Nye, C. D. Ovey, B. B. Roberts, Miss M. M. Sweeting, C. W. M. Swithinbank and W. H. Ward.

University College of Rhodesia and Nyasaland

IN the article on "The University College of Rhodesia and Nyasaland" in *Nature* of January 19, p. 139, it was stated that nearly half a million pounds was collected in East Africa for this project; the money was in fact largely provided by various groups in Central Africa. This sum is, of course, not adequate to finance a new university college. Indeed, the estimated capital expenditure for the College is £2 million (see *Nature*, 175, 181; 1955), of which £1,250,000 has been promised by the British Government from the Colonial Development and Welfare Fund.

Announcements

A SYMPOSIUM on "Aluminium in Electrical Engineering" has been arranged by the Aluminium Development Association during May 16–17, to be held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2. Inquiries should be addressed to the Aluminium Development Association, 33 Grosvenor Street, London, W.1.

AT the third annual general meeting of the Institution of Telecommunication Engineers, which is a professional body of radio, electronics and telecommunication engineers in India, Prof. K. Sreenivasan was elected president, and the following were appointed officers of the Institution: Sri B. V. Baliga, Dr. Lal C. Verman, Sri D. D. Lakhanpal, Sri B. S. Rau, Sri S. S. Aiyar, Dr. Ram K. Vepa and Sri N. V. Gadadhar.

THE spring meeting of the Institute of Metals, organized jointly with the Associazione Italiana di Metallurgia, the Société Suisse des Constructeurs de Machines and the Schweiz Verband für die Materialprufungen der Technik, will take place during April 29–May 4. All the scientific sessions will be held in London at Church House, Great Smith Street, S.W.1, except the May Lecture, which will be given in the Royal Institution, Albemarle Street, W.1. Details can be obtained from the Secretary, Institute of Metals, 17 Belgrave Square, London, S.W.1.

A PHYSICAL Society Conference on Physics of the Solid State, organized by Prof. L. F. Bates, will be held during April 8–10 in the Physics Department of the University of Nottingham. During the Conference, Prof. H. C. Urey, of the Enrico Fermi Institute for Nuclear Studies, University of Chicago, will deliver the Society's Guthrie Lecture at the University of Nottingham. The subject of his lecture will be "Some Chemical Limitations on Theories for the Origin of the Solar System". Inquiries should be addressed to the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7, marked for the attention of Miss Miles.

THE Anniversary Meetings of the Chemical Society will be held in the University of Cambridge during April 9–12. Prof. E. L. Hirst will deliver the presidential address on "Some Aspects of the Chemistry of the Fructosans" on April 11 at 11.15 a.m. in Lecture Room *A*, Examination Hall. Three symposia will be held during the period of the meetings. The sessions, which will run concurrently, will be devoted to: (organic) "Phosphoric Esters and Related Compounds"; (physical) "Reactions of Free Radicals in the Gas Phase"; and (inorganic) "Recent Aspects of the Inorganic Chemistry of Nitrogen". Further details can be obtained from the Chemical Society, Burlington House, London, W.1.

THE twelfth International Congress on Occupational Health has been convened by the Permanent International Committee on Industrial Medicine, founded in 1906 in Milan. Helsinki has been chosen as the place of the Congress, which will be held during July 1–6. The Congress has been planned so that subjects considered of general interest, including industrial noise, evaluation of invalidity, industrial hygiene and human engineering, will be discussed at plenary sessions during the mornings. Other subjects, judged to be of interest only to a limited number of members, will be dealt with at afternoon sessions. Registration forms (to be returned before April 1) and other information may be obtained from the Organizing Committee, Haartmaninkatu 1, Helsinki, Finland.

ERRATUM. In the communication entitled "Manganese Deficiency in *Chlorella* under Heterotrophic Carbon Nutrition" by Reisner and Thompson (*Nature*, December 29, p. 1473), Table 1, the dry weight of manganese-deficient material in line 3 is incorrect; for 7·3 read 4·3.

EPIDEMIOLOGY OF POTATO BLIGHT

A MOST successful symposium on factors which affect the severity of potato blight disease was arranged by the British Mycological Society on January 5 at the London School of Hygiene and Tropical Medicine. Dr. R. V. Harris, chairman of the Society's Plant Pathology Committee, presided and introduced six speakers, who together covered a wide range of new knowledge about the disease and its causal fungus, *Phytophthora infestans*.

Dr. N. F. Robertson, of Cambridge, started from the widely accepted assumption that blight overwinters in the tubers, and that only a proportion of such overwintering tubers gives rise to infected plants. He then directed attention to a delay in the development of stem lesions resulting from inoculations early in the year. Although such lesions appeared within seven to fourteen days of inoculation, they did not begin to develop epidemically until some forty days later. This lag between the first infection and the 'real' infection occurred in both greenhouse and field experiments. Inoculations on the young leaves and near the stem apex were more effective than those near the base of the stem. Dr. Robertson posed the questions (1) whether the infection which causes the main epidemic could arise as dispersion from earlier stem lesions, and (2) whether such dispersion could be forecast by survey. There is no doubt about the fact of epidemic blight development, but Dr. Robertson gave an interesting detailed study of the development pattern of an epidemic within a particular crop.

The early phases of potato blight epidemics were considered by Dr. J. M. Hirst, of Rothamsted, with the view of finding reasons for their relative constancy in time. He also presented examples of delayed development of stem lesions, showed that early lesions occurred on only 0–1·4 per cent of the emergent plants, and sought an explanation of the delayed development in a study of the ecoclimate within the crop. Comparisons of such climate with weather conditions in a screen at 4 ft. above ground did not indicate large differences, but showed that temperatures generally rose higher in the crop than in the screen during early growth. The relative humidity did not fall so low in the crop newly emerged as it did in the screen, but among slightly older plants the relative humidity might be lower. During the epidemic development of blight, temperatures were about the same in crop as in screen, but the relative humidity was higher in the crop. The concentration of spores of *P. infestans* in the air was also considered and found to be less than 100 per cubic metre until the blight epidemic was well developed. Dr. Hirst envisaged an outbreak of blight as resulting from the removal of successive barriers: (1) foliage must be above ground; (2) fungal infection must arise above ground; and (3) there must be conditions (principally of weather) suitable for infection to take place.

Dr. J. Grainger, of the West of Scotland Agricultural College, advanced an explanation of blight phenology based upon new investigations of host-plant physiology and known influences of weather conditions which affect the parasite. He described field experiments and inoculation tests which showed that the potato plant is very susceptible indeed to attack by *Phytophthora infestans* in the early stages of growth; then follows a period of very low susceptibility before the second susceptible epidemic stage is reached. The term 'disease potential' was, however, used for these changes, for 'susceptible' and 'resistant' should properly be reserved for the relative tolerance of a species or variety for disease. Several detailed growth-cycle analyses of all parts of the host through its whole cycle of growth showed that the rate of growth was most rapid, and the percentage of total carbohydrate in the whole plant was low, at the time of low disease potential, and *vice versa*. These two factors, the only consistent ones found, were combined in the C_p/R_s ratio—the weight of total carbohydrate in the whole plant (C_p) divided by the residual dry weight of the shoot (R_s). The height of this ratio provided a measure of the disease potential, being high when it was high, and *vice versa*. Very high values of the ratio in the youngest sprouts conferred a hypersensitive disease potential which was for a short time capable of eliminating the disease. Then the ratio (and disease potential) fell rapidly to low values, so that if any blight lesions on the stems or leaves had escaped the hypersensitive phase, they would not develop until the ratio began to rise again (for the time of the summer epidemic). The rate of development of a blight epidemic depends largely on the height of the C_p/R_s ratio at the time of its first appearance. High-ratio second early crops sustained an early attack of blight in 1955, while at the same time low-ratio maincrops were not diseased. If crops are planted at different times of the year, they have different ratio values at the time of the usual blight epidemic and are attacked with differing severity but always according to the relative ratio value. Since dormant tubers have moderate C_p/R_s ratio and disease potential, the ratio provides an index to the host's disease potential for blight at all times of its complete growth cycle.

Conditions which affect the parasite assume major importance at the start of the main epidemic, and Dr. Grainger described the 'Auchincruive' self-calculating blight forecast recorder. This can be calibrated to record the weather specifications of either Beaumont or Bourke, and a further development was the 'Auchan' blight forecast alarm. Protective spraying according to the first valid forecast always gives maximum performance in areas where protective spraying is economic. Blight appears underground on the tubers soon after it occurs on the foliage; it frequently appears first on the undersides and seems to have a close relation with the amount of soil moisture.

Weather conditions which presage blight development have been derived either empirically by survey (for example, Beaumont, Bourke), or fundamentally, by laboratory studies of the environmental needs of the fungus (for example, Crosier). Mr. P. M. Austin Bourke, of the Irish Meteorological Service, stated this and added a new approach—the use of synoptic weather charts in forecasting a disease outbreak. 'Blight weather' is provided by an influx of tropical maritime air, and this is given by three types of

system: (1) a series of wave depressions (in which conditions between the depressions provided suitable weather for practical spraying); (2) a quasi-stationary front; and (3) a complex 'puddle' low system. On the other hand, a direct outbreak of polar air, with the establishment of a blocking ridge, gave weather which was completely unfavourable for blight development. Mr. Bourke gave details of six sets of conditions in three summer months of 1956, when there was good agreement with other methods of forecasting blight. The dates are rather important, for they were matched by reports from other parts of Britain: June 8–12 and 16–21; July 4–8, 13–18 and 29–30; August 15–19. Particular interest attached to the period during July 13–18, which initiated the main blight outbreak in England and Wales, and could have been forecast satisfactorily either by local specification or by the new synoptic method. Mr. Bourke had found his own specification of suitable weather conditions to work in Chile, but pointed out that different regions would probably need different specifications.

Mr. E. C. Large, of the Plant Pathology Laboratory, Harpenden, outlined the results from seven years work on blight forecasting by Beaumont rules, with comparisons of yield build-up and spraying experiments. There had been a useful degree of success, particularly in 1956. It was possible to recognize certain blight years (for example, 1948, 1950, 1953) when there were economic gains from protective spraying. Other years (for example, 1952) had blight so late in the season that there was actually a loss in overall yield from protective spraying, mainly from direct damage caused by the passage of tractor wheels. Protective spraying was not economic in northern England because blight caused so little loss in yield. Timing the spray about one week before blight covered 0·1 per cent of the foliage gave good results in a 'blight year', but spraying when there was more than this amount of disease gave a much poorer performance. Tuber blight losses were large on some varieties, but 57 per cent of crops had less than 1 cwt. of blighted tubers per acre. The average loss was about 3·5 cwt. per acre, but this type of damage was higher in years when blight was severe on the foliage, and was generally higher in the north of England than in the south.

Potato blight control in North America was reviewed by Mr. A. E. Cox, of the Plant Pathology Laboratory, Harpenden. The consumption of potatoes per person per annum is there less than half that in the United Kingdom, and growth of the crop is more specialized. Blight presents a serious problem in Maine, Prince Edward Island, and the maritime provinces of Canada. There is a shorter growing season (averaging 120 days in the United States, as against 160 in Britain) and many crops are lifted while the tops are still green. American growers are therefore interested in haulm-killing materials (*sodium arsenite*) and methods (rotary beating). The growers are more concerned to control small amounts of blight on the tops than we are in Britain. Sprays have to be given for the control of insect pests such as Colorado beetle, leaf hoppers and flea beetles, so that sprays for blight control are incorporated in this wider programme. Organic fungicides such as the dithiocarbamates are far more widespread than copper sprays to counter blight. Potato rows are 36 in. apart, and tractor wheel guards are used to minimize haulm damage. Sprays are almost invariably at high volume (100 gallons per acre) and are applied to the upper surface of the foliage; no drop lances are used.

Several interesting matters arose from extensive discussions which took place at intervals during the symposium. It appeared that spores of *P. infestans* lose their viability fairly quickly even at relatively high humidities close to the leaf surface. Blight can develop on fields which have not themselves had primary foci of early lesions, and it would scarcely be practical to control primary foci in Britain. More attention should be paid to the elimination of all blighted tubers from stocks of seed, and to the destruction of waste growing tubers, on which stem lesions were frequent. The C_p/R_s ratio rose initially and later fell in potatoes grown from true seeds, but the rise was not high enough to confer hypersensitivity, as happens in plants grown from tubers.

THE SCIENCE MASTERS' ASSOCIATION

ANNUAL MEETING

BETWEEN seven and eight hundred science masters and guests attended the annual meeting of the Association, held in the University of Cambridge during the first week in January. After an introductory illustrated lecture on Cambridge, by Mr. G. F. Hickson, members were welcomed to the University by Lord Adrian, Master of Trinity College, and the Fellows of the College, who gave a reception in the Great Hall of the College.

The large examination hall of the University was filled to hear the address by the president for this year, Sir Alexander Todd (professor of organic chemistry, University of Cambridge). Sir Alexander said that the English educational system needed to be changed rapidly to meet the demand for more technologists, and quoted striking figures to show the extent to which Britain lags behind the United States and Russia. He thought that we still tend to maintain a system which might have sufficed in the early days of the industrial revolution, and that if this system were adhered to, our economic ruin was certain. "Trade," he said, "now follows the technologist and not the flag."

Sir Alexander thought that specialization in secondary schools might be reduced, so that students who wished later to turn to a scientific career might not be discouraged by having abandoned science at an early age. He commended the Scottish system, of following many subjects up to university standard, as being more likely to produce the required result.

Prof. N. F. Mott, professor of experimental physics in the University of Cambridge, speaking on "Science in the Universities and Schools", also dealt with specialization, and said that university courses including both arts and science subjects are under consideration at Cambridge; thus, for example, Part I of a Tripos might be taken in an arts subject, and Part II in science subjects. An optional postgraduate course is also being discussed. Prof. Mott supported Sir Alexander Todd's plea for less specialization in the sixth forms of schools, and also advocated more school contacts with industry.

An afternoon discussion on "Technical Education and the Schools" was introduced by Dr. K. B. Hutton, headmaster of Hatfield School, the chair

being taken by Mr. W. G. Rhodes, education and training officer of Arthur Lee and Sons, Ltd., steelmakers, of Sheffield. Dr. Hutton thought that a great deal of time was wasted by the retention of Latin in the school curriculum; this time might more usefully be employed in practical subjects such as woodwork, metalwork, and engineering drawing. He also thought that German and Russian might with advantage be substituted for languages now more commonly studied. Dr. J. M. Fletcher, of the Chemistry Division of the Atomic Energy Authority, thought that a good general grounding in English, mathematics and science was of more importance than any extensive practical or technical training. He said also that the very high standard demanded for university entrance scholarships did great harm, and he would have liked to see scholarships awarded at a level not much above that of the present Ordinary level standard.

On the last morning another discussion was held, on "The Recruitment and Training of Science Teachers". This was intended more particularly for teachers in secondary modern and technical schools, and was introduced by Mr. W. H. Palmer, lecturer at Homerton College, Cambridge. Mr. Palmer said that it is much more important that teachers should be enthusiastic than that they should have a large amount of factual knowledge. The percentage of science graduates in modern schools in 1953 was only 15, compared with 79 in the grammar schools, so that it was to the training colleges that the modern schools must look for their further supply of science teachers. Some training colleges, with this end in view, have started third year supplementary courses in science, for students just qualified or for serving teachers. Mr. E. R. Franklin, of Impington Village College, thought that all teachers of science should graduate in two or three subjects, and that more teachers might be obtained if the 'A' stream in modern schools were encouraged to take five subjects in the General Certificate Examination and were then transferred to the sixth forms of grammar schools. Mr. C. D. L. Brereton, warden of Bottisham Village College, thought that authentic knowledge was most important for the teacher. For example, the teacher who taught gardening should have had a professional training in horticulture, and in urban areas the teachers should have had real experience of industry. In the ensuing discussion, it was generally agreed that the training colleges should teach more than one branch of science.

The other usual activities of the meeting had, owing to exigencies of time, to be more tightly packed than ever. They included lectures by Profs. A. L. Banks and H. J. Emeléus, Drs. P. Sykes, G. C. L. Bertram and R. A. Lyttleton, and by Messrs. E. J. H. Corner and M. Ryle. Prof. J. F. Baker, together with Mr. C. W. Oatley and Mr. P. de K. Dykes, gave an evening lecture in the large lecture theatre of the Engineering Laboratory. The Science and Religion Group of the Association was addressed by the Rev. J. S. Bezzant, dean of St. John's College, and had a gratifying increase in membership. The exhibitions by publishers, manufacturers and members were this year very adequately housed, and both members and exhibitors expressed their appreciation of the arrangements made.

At the annual business meeting, members stood in silence in tribute to the memory of Mr. F. L. Swift, general secretary of the Association, who died suddenly a few days before the meeting. It was agreed that Dr. H. F. Boulind, former general secretary, should be acting secretary until a new appointment can be made.

The next meeting of the Association will be in the University of Leeds, during December 31, 1957–January 3, 1958.

SCIENTIFIC MAN-POWER IN THE CIVIL SERVICE

THE ninetieth report of H.M. Civil Service Commissioners, covering the period April 1, 1955, to March 31, 1956 (H.M.S.O. 2*s*. 3*d*.), refers to greater difficulties than before in recruiting, and to maintain a sufficient flow of recruits without lowering the standard of entry, changes in methods of selection were introduced, including the refunding of a larger proportion of travelling expenses incurred by candidates attending examinations or interviews, while from April 1, 1956, arrangements have been made to pay up to 30*s*. a night to candidates who are obliged to spend a night away from home to attend examinations or interviews. The quality of candidates in the open examinations was maintained except for the Administrative Class, in which the proportion of acceptable candidates was lower than usual, and with a fall of nearly 30 per cent in numbers as well, only thirty-one of the fifty vacancies could be filled. There was also a serious decline in the number of applicants for posts in the Senior Branch of the Foreign Service and only fourteen candidates were declared successful against the eighteen vacancies advertised.

For the Scientific Classes continuous open competition is still used and the number competing for Senior Scientific Officer posts generally offers an adequate field for selection. There was a slight decline on the previous year in Scientific Officer/Patent Examiner candidates but the quality of the Scientific Officer candidates was satisfactory, and revised salary scales and conditions of service may increase interest in the competition for Patent Examiners. The competition for research fellowships, of which five senior and seven junior were awarded, attracted a large entry and the standard of candidates was high. These fellowships, the senior ranging from £950 to £1,150 a year and the junior from £600 to £800, enable the holder to carry out fundamental research into specialized aspects of the work of several departments. Some 1,800 applications were received for about 650 posts in the Experimental Officer class, and the Selection Board from 1955 has travelled, wherever practicable, to interview at their place of work candidates already employed in government establishments.

Difficulty was again experienced in recruitment to almost all posts in the engineering and technical fields, and while there was no lack of applicants for most posts, their general quality was poor. Selection of a short list of candidates for interview was often difficult and the Commissioners were concerned to notice how many candidates fell short of the basic technical knowledge implied by the qualifications they held. In all competitions for professional posts good honours graduates with industrial experience outside the Civil Service were extremely rare and, unless the situation changes, there may well be, in years to come, a serious shortage of first-class men

capable of carrying the heavy responsibility of higher posts in government departments in the engineering field. From June 1955 recruitment to the Factory Inspectorate has been made continuous and as a result of this change almost all the accumulated vacancies were filled, though there were very few suitable candidates with engineering experience. Most successful candidates were arts graduates with little or none of that experience on the factory floor which, though not essential, would increase their value.

Arrangements by which the Commissioners are consulted in making acting promotions from the sub-professional to the professional classes of the Works Group and related classes of officers not eligible for open competitions continued to work smoothly; and a rather higher number of vacancies in the *Executive Class than last year were filled from school* leavers of 17½–19 years without lowering the minimum standard, but there were no suitable candidates to spare. The universities have welcomed the Commission's decision to invite a number of *younger members of the Administrative Class to act* as links between the Civil Service and their former universities or colleges, by standing ready to answer inquiries and by making occasional informal visits to talk to individuals, and the scheme was put into *operation in November 1955.*

THE NATIONAL RESEARCH COUNCIL OF CANADA

REPORT FOR 1955–56

THE thirty-ninth annual report of the National Research Council of Canada covers the year 1955–56 and includes, besides the President's report and the financial statement, the annual report of Canadian Patents and Development, Ltd., for the year ended March 31, 1956*. An entirely new industry has been established in Canada, based on the Research Council's patent for oil additives to extend the life of lubricating oils, and the Corporation considers that the agreements promise substantial revenues. Development of the Cambron process for direct oxidation of ethylene to ethylene oxide progresses slowly, but an improved type of reactor is being tested which promises more efficient operation and lower costs of construction. During the year, the National Research Council, which now employs a scientific staff of 558, all but six of whom are engaged in research, with a technical staff of 753 and 814 general service and administrative personnel, distributed 2·6 million dollars for pure research in the universities in 420 grants and 277 scholarships and dealt with 7,600 technical inquiries from Canadian industries. Of the research grants, 300,000 dollars was administered by the Atomic Energy Control Board.

In the Division of Applied Biology, a jacketed cold-storage room has been used with advantage to store fresh fruit and vegetables, and it has been found that the sticky layer on the outside of the cells of some helophilic bacteria is deoxyribonucleic acid, loss of which is related to the salt requirements of the helophilic bacteria. Studies of rats during their acclimatization to cold showed that though heat production in shivering continues at a high level, there is a reduction and finally a disappearance of shivering, and the possibility of fundamental changes in muscle behaviour is being investigated. The Atlantic Regional Laboratory at Halifax has investigated the fermentation of apple juice, storage of potatoes, preservation of cod fillets and made considerable progress in its study of the chemical composition of pitch formed in pulp and paper mills. The Prairie Regional Laboratory at Saskatoon has almost completed its investigation of the major factors affecting the production of glycerol and arabitol by honey yeasts in deep tank fermentation and has converted starch and other carbohydrates to cyclic glycols by hydrogenolysis under mild *conditions.*

In the Department of Applied Chemistry considerable progress has been made in explaining the mechanism of formation of the initial products in the oxidation of iron and its alloys and in a study of the *phase diagram of the calcium–silver system. The* thermal cracking of heavy Canadian crude petroleum has been studied, and the effects of pressures up to several thousand atmospheres on the equilibria of the system carbon dioxide–benzene–benzoic acid. *Methods of improving gravitational sedimentation* have been examined and an inexpensive method of preparing water-resistant silica has been developed. In the Division of Pure Chemistry, the major interest of the Organic Chemistry Section is still the investi*gation of alkaloids and much work has been done on* their biogenesis as well as on their structure. The study of the rates of solvolysis of the alkyl benzene-sulphonates and methane sulphonates continued, and sixty-four steroids have been synthesized and their infra-red spectra examined. Deuterated hydrocarbons have been synthesized by a new method and much information obtained on the reactions of CF_3 radicals by the photolysis of hexafluoroacetone. The mercury photosensitized decomposition of ethylene, propylene and the butylenes has been investigated with a fast flow system attached to a mass spectrometer and the self-diffusion of the chloride ion in alkali chlorides is being determined by a new technique, while considerable progress has been made in investigating the semi-conductor properties of single crystals of anthracene, and the sorption of undissociated acids has been shown to be a general property of fibres, such as wool, silk and nylon, which contain peptide bonds.

The Division of Applied Physics has successfully investigated means for reducing noise in industry, giving special attention to the couch noise of newsprint machines, for which a comprehensive solution has been provided in principle, and the work is now being applied to paper mill machinery. It is expected that the Canadian unit of electrical resistance will be established on a fundamental basis during 1956–57. Much attention has been given to problems presented by the anomalous drying of newsprint in paper mills, and in these investigations a resistance thermometer that is not affected by lead resistance has been developed. The newly established Interferometry Section evolved several new techniques and expects to give more attention to research and development in future. A new airborne controlled method of aerial triangulation of high accuracy and efficiency has been developed and comprehensive work done on the distortion characteristics of cameras

* Thirty-Ninth Annual Report of the National Research Council of Canada, 1955–56. Pp. 50. (N.R.C. No. 3970.) (Ottawa: Queen's Printer, 1956.)

used in photogrammetry. Research on the techniques of measuring high-intensity gamma-ray sources continued and also on the friction of ice.

The Division of Pure Physics continued to study the behaviour of cosmic rays as they penetrate matter, and measurements taken in 1954 and 1955 in two cruises, one to the Arctic and the other to the Antarctic, have now shown that the Earth's magnetic field as it affects cosmic rays differs considerably from that derived from surface geomagnetic measurements. Completion of work on the low-temperature electrical and thermal conductivity of the alkali metals indicates that the fundamental theory is seriously inadequate and for thermal conductivity a new semi-theoretical expression has been derived which accounts well for data over a wide range of match. Investigation of the spectra of polyatomic free radicals produced by the flash method of photodecomposition continued and the rotational Raman spectra of benzene, allene, cyanogen, butatriene, diacetylene and dimethylacetylene have been photographed under high resolution and their moments of inertia determined. Some work has been completed on a rigorous treatment of the central field-independent-particle nuclear shell model on the basis of the variational principle, and crystal structure studies made of the isomorphous dihydrate of lithium, sodium and silver dithionates, of acridiene II and of some aliphatic dibasic acids and their potassium salts.

The Division of Medical Research in 1955 awarded 145 grants-in-aid of research, in addition to seven consolidated grants, totalling 652,056 dollars, and of these, thirty-one grants were for cardiovascular research, to which a proportion of certain consolidated grants is also devoted. A Canadian Heart Foundation is now to be established, and the Council, on the recommendation of the Advisory Committee on Medical Research, is creating a new category of medical research associate, six of whom were expected to be appointed in 1956.

The Division of Building Research opened a small Atlantic Regional Station in Halifax during the year and the Prairie Regional Station at Saskatoon concentrated with laboratory studies of cold-weather building problems. The Fire Research Section continued its studies of major fires in the Ottawa area, field studies of housing problems were made in many parts of the country, regional soil temperature observations were further extended and the effects of frost were studied in connexion with the whole problem of winter construction. Much of the work of the Division of Mechanical Engineering continues to be related to defence, but that for industry is increasing. An investigation of the icing of helicopters was undertaken for the Royal Canadian Navy and instruments designed and constructed during the year have included a flame detector for use with gas turbines in flight or on the ground, devices and techniques for investigating 'howling' combustion, a wave profile recorder, preliminary designs for air-speed measuring devices for navigating helicopters and control systems for a pilot supersonic tunnel, a wave-making machine, and a ship-model profiling machine.

About half the work of the Radio and Electrical Engineering Division is on defence projects. In preparation for the International Geophysical Year an automatic radar system was designed for recording the aurora and the prototype tested continuously for eight months. Studies are being made of the fundamental electrical and optical properties of dielectric crystals, and a Czochralski-type furnace has been built to produce the superpure silicon single crystals needed for a study of silicon transistors. Fundamental antenna studies included development of a new type of two-dimensional slotted wave-guide array, the use of ferrites at microwave frequencies, and the performance of a slot in a dielectric-coated cylinder. A merchant marine radar of exceptionally good short-range definition and long-range performance has been developed and constructed, but the microwave position-fixing system developed for inshore survey use required certain modifications. An electrical thermometer has been designed which provides continuous indication of the temperature in freshwater lakes at various depths, and an investigation of the explosion hazard of static electricity generated by grain handling is almost complete. A radio survey in Banff and Yoho National Parks indicated that a system operating in the 152–174 Mc./s. band and consisting of two base stations and one automatic repeater station would provide communication cover to most of the warden stations and continuous coverage along the Trans-Canada Highway. The cardiac defibrillator-stimulator and electronic device developed for resuscitation of the heart from fibrillation is now being manufactured under licence and development of blood pressure measuring equipment for inclusion in the resuscitator continues.

INDUSTRIAL ACCIDENTS

THE annual report of the Chief Inspector of Factories for 1955* records the lowest accident-rate yet achieved, although the number of accidents, 188,403, was 1·2 per cent greater than in 1954, the factory population being 2·5 per cent higher and the number of factories with power 0·4 per cent greater than in 1954. Since 1953 the accident-rate for women has increased, and the Chief Inspector attributes this largely to the general rise in the number of women employed, of whom many are new to industry. He stresses the responsibility of management for special care to protect those entering industry for the first time and completely unfamiliar with their environment, as well as the importance of proper induction, training and supervision for young persons.

A separate chapter of the report reviews the changes in the rubber industry since 1922 in relation to the Indiarubber Regulations, 1955, prohibiting the use of carbon disulphide in the cold-cure process of vulcanizing in proofing cloth with rubber, which came into force during the year, and the Chief Inspector comments at greater length than usual on factory medical and nursing services. An outstanding feature of the year was the inception of a survey of conditions affecting health in all factories in Halifax, and of another survey of such conditions in the pottery industry. Another feature was the increased attention given to factory design. The Midland Regional Board for Industry sponsored some research into relative costs and merits of various types of factory premises, including the methods and costs of construction and the effect of the different types on production.

The increase in mechanization throughout industry generally is eliminating much heavy manual and

* Annual Report of the Chief Inspector of Factories for the year 1955. Pp. 275. (Cmd. 8.) (London: H.M. Stationery Office, 1956.) 9s. net.

dirty work formerly undertaken in factories, but the new methods of production often bring new hazards in more complicated form. Even where full automation would scarcely be worth while, firms are giving serious thought to some degree of electronic control, but the limit placed on automation by the need to extend and improve the training of the necessary technicians is generally recognized. The development of automatic control equipment will tend to increase safety in the heavier industries, but the Chief Inspector points out that it may be necessary, in the interest of safety, to give much more thought to electrical circuitry and programming. The use of electronic computers to extend our basic scientific knowledge in many industrial applications, such as fluid flow, heat transfer and electrical transients, and to solve problems in these fields, also bears on the improvement of industrial safety. The greatest single cause of accidents on electric supply systems remains the misconduct of work involving the handling of, or approach to, conductors, especially high-voltage conductors.

The control of nuclear reactors places a heavy responsibility on the engineer for the design and maintenance of reliable equipment to supervise critical and dangerous fission processes. The uses of ionizing radiations in industry are now well established, and, besides the Conference at Geneva on the Peaceful Uses of Atomic Energy, the outstanding events of the year in this respect were the publication in May of the revised "Recommendations of the International Commission on Radiological Protection" and the transfer, at the end of the year, of the radiation film badge service from the National Physical Laboratory to the Radiological Protection Service run jointly by the Ministry of Health and the Medical Research Council.

The Chief Inspector believes that the cumulative effect on production and working conditions of a number of changes in mechanization and automatic control in relatively small items is probably much greater than that of the more obviously impressive examples of full automation in the larger plants, and he reiterates that accident prevention schemes, however excellent on paper, are doomed to stagnation and ultimate failure without a genuine and continuing interest by management at the highest level.

THE INTERNATIONAL CIVIL AVIATION ORGANIZATION STANDARD ATMOSPHERE

IN 1924 the International Commission for Air Navigation devised a standard atmosphere[1] to be used in the graduation of aircraft pressure altimeters to give approximate readings of height and for the comparison of aircraft performances such as attempts at height and speed records necessarily made in different atmospheric conditions. This standard atmosphere approximated, probably deliberately, to mean conditions over western Europe. The specification, briefly, was: acceleration of gravity, 980·62 cm./sec.^{2} at all heights; pressure at zero height, 1,013·25 mb.; temperature at zero height, 288° K.; lapse rate of temperature, 6·5° C./km. to 11 km., and zero above. Graduation with this atmosphere gave, in general, much more accurate height readings on aircraft altimeters than the previously used assumption of temperature 50° F. at all heights. No upper limit to the standard atmosphere was prescribed in the specification, but this was of little importance because it was many years after 1924 before aircraft reached heights at which its specification was quite unrealistic. In 1954 the International Civil Aviation Organization revised the International Commission for Air Navigation standard[2] slightly by specifying height in terms of geopotential units. The geopotential height H in c.g.s. units at geometric height z is given by

$$\frac{1}{980{\cdot}665}\int_0^z g\,dz$$

More important than this, the Organization recognized that the standard atmosphere could be used as a suitable standard reference for the upper air, except as regards water vapour, up to an altitude of about 20 km. in temperate latitudes. The extension of the standard atmosphere above 20 km. as an approximation to average conditions at those altitudes must, it was stated, await the collection and analysis of a considerable number of reliable upper air soundings.

A committee of representatives of a number of United States organizations, including the Air Force Air Research and Development Command, the Air Force Geophysics Research Directorate, the Ballistics Research Laboratory, the National Advisory Committee for Aeronautics, the National Bureau of Standards, the Naval Research Laboratory and the Weather Bureau, has now decided on representation of the atmosphere up to 300 km. The data up to about 32 km. appear to have been obtained from radio-sonde observations and presumably at higher levels from a combination of measurements by rocket-borne instruments, and inferences from the luminescence of meteors, transmission of sound to great distances and atmospheric tides. The Committee, the address of which is Geophysics Research Directorate, 415 Summer Street, Boston 10, Massachusetts, U.S.A., had recently distributed a summary of tne extension in tabular and diagrammatic form[3].

The extension links with the International Civil Aviation Organization atmosphere at the foot and has the constant temperature, 216·6° K., of the International Civil Aviation Organization lower 'stratosphere' to 25 km. Then comes the rise of temperature with height associated with the ozone layer, giving a temperature between 47 and 53 km. of 282·66° K. Above the 'ozone layer' temperature falls again with height to the cold layer, in which in the real atmosphere noctilucent clouds are seen, at about 80 km.; the temperature at 75 and 90 km. is 196·86° K. The temperature then rises again with height as we ascend through the 'ionosphere' until at 300 km. it is taken to be 1,537·86° K. The temperatures in the 'ozone layer' are 10 deg. C. higher and those in the 'cold layer' about 10 deg. C. lower than the values adopted by the United States Rocket Panel in 1952. The specification for the levels from 20 to 32 km. has been adopted as a United States Standard and the Committee is planning to obtain international acceptance for it. The 32–75 km. region is termed "tentative" and the region above 75 km. "speculative". Besides temperature, the summary table gives lapse-rate, molecular scale temperature (kinetic temperature × ratio of molecular weight of air to molecular weight

of air at sea-level), molecular weight, and pressure. Detailed tables are now in course of preparation by the Geophysics Research Directorate and will be available shortly in limited numbers. A final edition will be printed by the United States Government Printing Office and sold in the usual way.

The new 'atmosphere' based on excellent authority will undoubtedly be of great value to all concerned with the designing for research or military purposes of missiles which can reach the great heights concerned, and also for calculations on such matters as the scattering of light in the upper atmosphere.

[1] International Commission for Air Navigation, Paris, Official Bulletin, No. 7 (1924).
[2] International Civil Aviation Organization. Manual of I.C.A.O. Standard Atmosphere. Doc. 7488. (Montreal, 1954.)
[3] Announcement. Committee on Extension to the Standard Atmosphere. U.S. Weather Bureau and Geophysics Research Directorate. (Boston, 1956.)

PHARMACOLOGICALLY ACTIVE LIPID-SOLUBLE ACIDS OF NATURAL OCCURRENCE*

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IT is well known that a number of substances with intense pharmacological actions exert regulating functions in the living organism. The first known compounds of this kind were amines and quaternary bases like histamine, adrenaline and acetylcholine. During recent years another group of substances has become fashionable: pharmacologically active polypeptides. They affect smooth muscle activity and vascular tone, and are significant in inflammation and other pathological reactions. Both amines and peptides are related to the proteins. The amines are derivatives of amino-acids, and the polypeptides are split-products of proteins.

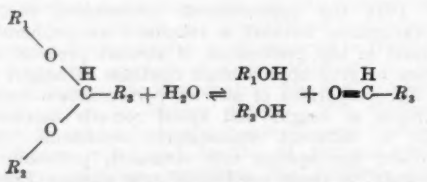
There is yet another group of active substances which are entirely different chemically, namely, lipid-soluble acids. Some of them are certainly related to lipids, others may or may not be. Usually the lipids are regarded as sources of energy and as structural elements in the body; but in the past few years evidence has accumulated that not only are they involved in specific biochemical reactions such as blood clotting, but also that some of them exert pharmacological effects which may have physiological or pathological significance.

'Darmstoff'

I came across one of these compounds when working on isolated intestinal preparations. It is an old observation of Weiland[1] that if bath fluid, in which isolated segments of intestine have been suspended for some time, is tested on another segment of intestine, the latter will react either with a rise in tone or an increase in its spontaneous contractions. Le Heux[2] concluded that this activity was due to choline which had diffused from the intestinal segment into the bath fluid. The effect of the bath fluid like that of choline was abolished by atropine, and choline was identified in the bath fluid. However, another smooth-muscle stimulating substance diffuses into the bath fluid in addition to choline, because when tested on an atropinized segment, which is insensitive to choline, the fluid still has a stimulating effect[3]. This substance, which contracts the atropinized intestine, I called 'Darmstoff'. The first samples of 'Darmstoff' were obtained from such bath fluids in amounts of the order of micrograms. Later, 'Darmstoff' was prepared from intestinal tissue itself and extracts from horse or ox intestine gave sufficient material to study its properties[4].

In paper electrophoresis experiments at *p*H 7·6, 'Darmstoff' moved towards the anode, that is, it behaved like an acid. In the free-acid state 'Darmstoff' was found to be easily soluble in alcohols, ether and ketones, but only slightly soluble in water. On the other hand, it formed water-soluble salts with alkali or alkaline earths. The acidic nature of 'Darmstoff' was further evident from its behaviour in liquid–liquid distribution. When distributed between water and ether at alkaline *p*H the gut-stimulating action was found in the water phase, but when the same distribution was carried out in an acidified system, the effect was found in the ether phase. This is the typical behaviour of a lipid-soluble acid, and by this behaviour 'Darmstoff' can be distinguished and separated from amines and peptides. The stability of 'Darmstoff' was found to be rather unusual. When boiled in *N* sodium hydroxide for 10 min., no appreciable loss of activity occurred, but when boiled in *N*/10 hydrochloric acid for the same time, there was considerable inactivation.

This was almost all we knew about the chemistry of 'Darmstoff' when I came to Great Britain in October 1955. Shortly afterwards, I was asked to give a lecture about 'Darmstoff' in Aberdeen and, during the discussion, Prof. W. O. Kermack and Dr. C. Long remarked on the unusual fact that 'Darmstoff' was more resistant to alkali than to acid. They suggested that this might indicate that 'Darmstoff' contains acetal groups. Acetals, the structure of which is as follows:



are formed by combination of an aldehyde with two alcoholic groups and are easily split into their components by acid but not by alkali.

In order to find out whether 'Darmstoff' contained acetal groups, I tested its reaction with fuchsin-

* Lecture given at the National Institute for Medical Research, Mill Hill, London, N.W.7, on October 10.

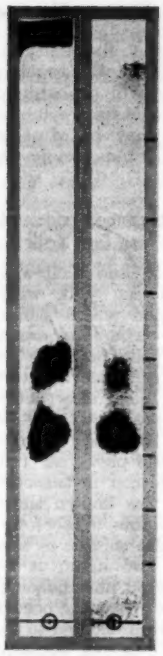
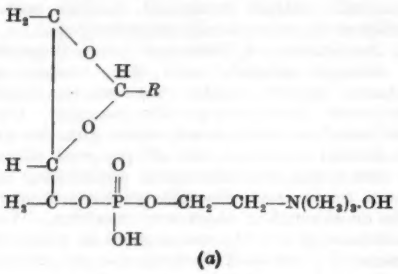


Fig. 1. Chromatograms of 'Darmstoff'. Left strip stained with Schiff reagent for aldehydes; right strip stained for phosphate. (From Vogt, *J. Physiol.*, 1957)

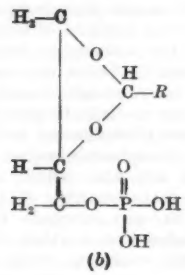
sulphurous acid. This acid, or Schiff reagent, gives a purple colour with aldehydes. The reaction was carried out on paper chromatograms of 'Darmstoff', using a methylethylketone–diethylamine mixture, saturated with water. After drying, the paper was at first incubated with acetic acid in order to hydrolyse any acetals and liberate the aldehyde component, and then the chromatogram was treated with the Schiff reagent. Such a chromatogram is shown in Fig. 1. A positive reaction was obtained in two spots; the upper one was sometimes rather weak. These spots appeared within a few minutes after contact with the reagent, provided that hydrolysis with acetic acid as described had been carried out previously. If this was omitted, it took several hours before the colour appeared. This strongly suggests that the reacting aldehyde groups were originally bound as acetals and had been liberated by hydrolysis during the preceding incubation in acetic acid, but that without this treatment they were slowly liberated by the acidity of the Schiff reagent itself.

Resistance to alkali together with sensitivity to acid is characteristic also of some phosphoric esters. As seen in the right-hand 'Darmstoff' chromatogram of Fig. 1 which had been stained with the phosphate reagent of Hanes and Isherwood[5], the areas which gave a positive aldehyde reaction contained phosphate as well. When such chromatograms, instead of being stained, were cut into transverse sections and each section was eluted and the eluate then assayed on the isolated rabbit duodenum, it was found that only the eluate from the area which corresponded to the lower of the two phosphate and aldehyde containing spots exerted gut-stimulating activity. In other words, it is the 'Darmstoff' itself which contains phosphate and aldehyde.

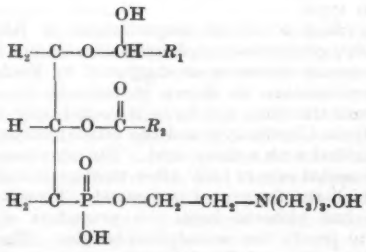
The finding that 'Darmstoff' is acidic in nature, lipid-soluble and contains phosphate and acetal groups, suggested an acetalphosphatidic acid; that means 'Darmstoff' would be a derivative of an acetal-phosphatide (plasmalogen), which lacks a base. The general structure of acetalphosphatide as suggested by Feulgen[6] is given in formula (*a*):



(*a*)



(*b*)



(*c*)

(*a*), Acetalphosphatide (plasmalogen) according to Feulgen; (*b*) acetalphosphatidic acid, corresponding to (*a*); (*c*) acetalphosphatide according to Klenk and Debuch

The nucleus consists of α-glycerophosphate. The phosphate is esterified with a hydroxyl-containing base—choline or ethanolamine. The two hydroxyl groups of the glycerol which are not bound to the phosphate are linked with a long-chain fatty aldehyde, giving a cyclic acetal. This compound is neutral because the basic group of the choline matches the one acidic group of the phosphate which is left free. The two other acidic groups of the tribasic phosphate are esterified. When the basic group, that is, the choline, is split off, the residuum contains two free acidic groups but no basic group, so that the resulting compound, shown in formula *b*, is an acid.

If 'Darmstoff' were to have this general structure, cleavage of the acetal linkage should result in free

fatty aldehyde and α-glycerophosphate. In fact, after mild acidic hydrolysis at 37° C., in 95 per cent acetic acid + traces of mercuric chloride, which acts as catalyst for acetal cleavage, a free lipid-soluble aldehyde and glycerophosphate could be demonstrated by paper chromatography. These experiments showed, however, that not all the phosphate in 'Darmstoff' extract was converted to glycerophosphate but that some of the phospholipid of the extract was resistant to mild acidic hydrolysis. Thus, 'Darmstoff' extract contained, besides acetalphosphatidic acid, other acidic phospholipids.

If the activity of 'Darmstoff' were dependent on the acetalphosphatidic acid the cleavage of this substance should render the acidic 'Darmstoff' hydrolysate pharmacologically inactive. However, when tested on the isolated rabbit gut, the hydrolysate showed a loss of only 50 per cent of activity. The remaining smooth-muscle stimulating activity did not result from the split products, glycerophosphate or aldehyde; these were inactive. When the distribution of activity was studied on paper chromatograms of 'Darmstoff' hydrolysate, the activity was found to be located in those areas which corresponded to the unchanged acidic phospholipids. Thus 'Darmstoff' seems to be a mixture of acidic phospholipids, and about half the activity is dependent on acetalphosphatidic acids[7]. About the nature of the phospholipids which are resistant to mild acidic hydrolysis, we have at present no definite knowledge. They may not only be other phosphatidic acids, but also phosphatides like phosphatidylserine or inositolphosphatides which are also acidic in nature. With regard to the fatty moiety of these unidentified phospholipids, we can conclude that they are not ester phosphatides like lecithin or cephalin, since they are not only stable to weak acids, but also to alkali. The fatty moiety could be of the sphingomyelin type.

According to recent experiments of Klenk and Debuch[8], genuine acetalphosphatides do not have the cyclic acetal structure as suggested by Feulgen, but are semi-acetals, as shown in formula (*c*). In this structure the fatty aldehyde is bound only to one of the glycerol hydroxyls and the other hydroxyl group is esterified with a fatty acid. The conversion to the cyclic acetal occurs only after treatment with alkali, by which the fatty acid is cleaved. Treatment with alkali has hitherto been the procedure commonly used to purify the acetalphosphatides. The 'Darmstoff' sample used for the present investigations was also treated with sodium hydroxide and it may well be that originally the acetalphosphatidic acid was a semiacetal having still one fatty acid.

If the conclusion is correct that 'Darmstoff', or at least part of it, is an acetalphosphatidic acid, then chemically prepared acetalphosphatidic acid should exert a gut-stimulating effect. Therefore, I prepared some acetalphosphatidic acid by alkaline hydrolysis of a preparation of acetalphosphatide obtained from Prof. Klenk and then tested the hydrolysate on the isolated rabbit intestine suspended in a 15-ml. bath. It contracted the gut in a dose of 0·5 μgm. This corresponds to the order of activity of the purest samples of 'Darmstoff' I have obtained. The active principle of the hydrolysate was certainly the acetalphosphatidic acid. Like natural 'Darmstoff', it was acidic in nature, soluble in organic solvents, and on paper chromatograms it occupied the same position as 'Darmstoff'; this area gave positive aldehyde and phosphate reactions. These findings confirm the conclusion that 'Darmstoff' consists in part of acetalphosphatidic acid.

Since the different phosphatidic acids are similar in their physicochemical properties, their pharmacological activities will probably depend mainly on free acidic groups and lipid solubility. Differences in the fatty moiety may be of secondary importance and probably numerous acidic phospholipids exert similar effects.

Slow Reacting Substance produced by Cobra Venom in Egg Yolk

Feldberg, Holden and Kellaway[9] had found that on incubation of egg yolk with cobra venom a substance is formed which stimulates the isolated guinea pig ileum. The contraction produced by the envenomed egg yolk proceeds remarkably slowly, hence the active principle was termed slow reacting substance. Its typical slow action on the isolated guinea pig ileum preparation is shown in Fig. 2, and is compared with the quick contractions produced by histamine. For the past year I have been working on this substance and it turned out to be a lipid-soluble acid. It was known that the slow reacting substance was soluble in acetone and in ether. I found that it is also soluble in butanol, benzene and light petroleum. So again it was a lipid-soluble compound. Since all pharmacologically active lipid-soluble substances of natural occurrence so far known are acidic in nature, I decided to find out whether this held for the slow reacting substance as well. Ether or alcohol extracts of envenomed egg yolk were distributed between water and ether. If this was done at alkaline *p*H, the slow reacting substance went into the water layer, but at acidic *p*H, into the ether. Thus, the slow reacting substance behaved like a lipid-soluble acid. Next it seemed reasonable to assume that the slow reacting substance was a fatty acid derived from the lecithin of egg yolk because cobra venom contains an enzyme, phospholipase *A*, which liberates one fatty acid from lecithin. By this reaction the hæmolytic lysolecithin and a free fatty acid are obtained; in the case of egg lecithin it is always an unsaturated fatty acid. The following findings prove that the slow reacting substance is indeed an unsaturated fatty acid derived from lecithin. First, the slow reacting substance behaved like an unsaturated fatty acid, in that it formed a lead salt which was soluble in ether. Secondly, the slow reacting substance was obtained not only by the action of cobra venom on egg yolk, but also under

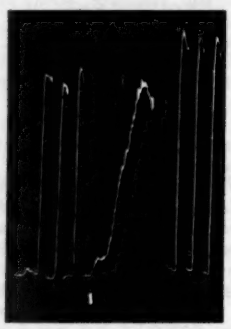


Fig. 2. Contractions of isolated guinea pig ileum preparation to slow reacting substance (at white spot) and to histamine (other contractions)

conditions when no other reaction but splitting of lecithin could have occurred. Thus, I used pure lecithin as substrate instead of egg yolk and incubated it with cobra venom in ether instead of water solution. The only enzymatic reaction which still occurs in this medium is the action of the phospholipase *A* of the venom, as has been shown by Hanahan[10]. When the fatty acids of this incubate were isolated, they acted like the slow reacting substance. Finally, the slow reacting substance was prepared by chemical hydrolysis of lecithin with sodium hydroxide[11].

Having shown that the slow reacting substance is an unsaturated fatty acid derived from lecithin, it remains to find out the nature of this smooth muscle stimulating unsaturated fatty acid. Egg lecithin is not uniform but differs in its fatty acid constituents, the main constituents being oleic and linoleic acids. Oleic acid is ineffective and therefore not identical with the slow reacting substance. Linoleic acid has a weak stimulating effect on the guinea pig ileum and some of the slow reacting substance activity may be due to this acid. The effect, however, is too weak to account for the whole slow reacting substance activity obtained from egg lecithin, which seems to be the effect of several unsaturated fatty acids. There are two other unsaturated fatty acids known to have gut-stimulating properties, but we do not know if they occur in egg lecithin. The one is the *cis*-vaccenic acid which was found by Laser[12] in blood and which is gut stimulating, and the other is the so-called *G*-acid, a *cis*-$\Delta 3$: 4-octadecenoic acid, which Gabr[13] found in the β-globulin fraction of human plasma.

We do not know whether the slow reacting substance exerts a physiological function. The fact that it is formed by the action of venom on egg yolk does not provide any evidence for assuming such a function. However, when considering a possible physiological role of the slow reacting substance we have to realize that whenever cobra venom is brought in contact with either plasma or organs of at least all the mammals so far examined, a slow reacting smooth muscle stimulating substance is formed[14]. It seems reasonable to assume that it is also an unsaturated fatty acid formed by the action of the venom on tissue lecithin. Since lecithin-splitting enzymes are not confined to venoms but occur rather widely in tissues, the release of pharmacologically active unsaturated fatty acids may be of significance for pathological and even physiological phenomena.

Other Lipid-soluble Acids with Muscle-stimulating Properties

'Darmstoff' and the slow reacting substance are not the only known acidic lipid-soluble substances with smooth muscle stimulating properties. 'Darmstoff' represents acidic phospholipids and the slow reacting substance unsaturated fatty acids. The chemistry of the other known lipid-soluble acids has not yet been sufficiently studied to allow their classification into one of these two groups.

Prostaglandin. This lipid-soluble acid was the first substance of acidic nature shown to have smooth muscle stimulating properties. It was found to contract the intestine and uterus of various species and to produce a fall in arterial blood pressure. Its presence was observed independently by Von Euler[15] and by Goldblatt[16] in prostate glands. The name was given by Von Euler. The acidic nature of prostaglandin was shown by electrophoresis[17]. It is soluble in organic solvents but unlike fatty acids and phosphatidic acids the free acid prostaglandin is easily soluble in water and can only to a small extent be extracted from aqueous solution by ether. Thus prostaglandin shows the peculiar feature, that although it is fairly lipid-soluble it is rather hydrophilic.

Vesiglandin. When Von Euler looked for the presence of prostaglandin in other tissues he found in the vesicular glands of monkeys a substance resembling prostaglandin in many respects but differing from it by having a relatively stronger hypotensive action and weaker smooth muscle stimulating effect. To this substance he gave the name 'Vesiglandin'[17].

Slow reacting substance A. Kellaway and Trethewie injected antigen (egg albumin) into perfused sensitized guinea pig lungs and examined the venous effluent for smooth muscle contracting substances. They found that the antigen liberated both histamine and a slow reacting substance[18]. This substance has been investigated by Brocklehurst, who called it slow reacting substance *A* in order to distinguish it from other slow reacting substances[19]. He showed by electrophoresis that it behaved like an acid[20]. Like prostaglandin, it is easily soluble in water even in the free-acid state and only slightly extractable with organic solvents from aqueous solution. Unlike prostaglandin, however, slow reacting substance *A* causes no fall in arterial blood pressure and has no effect on isolated uterus preparations. A substance with the same properties was found in perfusates of human asthmatic lung after injection of the antigen to which the lung was sensitive. Brocklehurst suggests that slow reacting substance *A* may well contribute to the symptoms of asthma and anaphylaxis, because he found that it contracts isolated bronchial muscle[20].

Irin. Extracts of rabbit iris contain a smooth muscle stimulating substance, which was called irin[21]. Irin causes a long-lasting atropine-resistant constriction of pupillary muscle *in vivo* and *in vitro*. By electrophoresis and liquid–liquid distribution Ambache showed that it is again a lipid-soluble acid[22]. Irin is released into the aqueous humour after stimulation of the trigeminal nerve, and Ambache assumes that it is the transmitter for the atropine-resistant meiosis which occurs on antidromic stimulation of the trigeminal nerve.

Fraction X. Fraction *X* is a smooth muscle stimulating substance which I found besides 'Darmstoff' in extracts of intestinal tissue[4]. Like 'Darmstoff' it is acidic and lipid-soluble, but it separates from 'Darmstoff' in countercurrent distribution. Unlike 'Darmstoff' it has a pronounced hypotensive effect. No detailed investigations have yet been carried out.

Irin and fraction *X* behave in distribution between water and ether or water and chloroform similarly to 'Darmstoff' and fatty acids. That is, in the free-acid state they go into the organic phase. They may be related to acidic phospholipids or fatty acids. On the other hand, prostaglandin, 'Vesiglandin', the slow reacting substance and slow reacting substance *A* are even as free acids so water-soluble that their greater part stays in the water phase after distribution.

Finally, we have to add to this list a smooth muscle stimulating substance recently found by Ambache and West[23] in extracts of rabbit skin.

This compound is soluble in 95 per cent acetone and moves to the anode in electrophoresis at *p*H 8·8.

All the substances discussed have in common the power to stimulate smooth muscles. There is no smooth muscle inhibiting substance known in this group. The fact that some of them produce a fall in arterial blood pressure does not contradict this statement, because this fall seems to be due to contraction of the pulmonary arteries. This has been shown, for example, for prostaglandin by Von Euler. The contractions these substances produce on isolated smooth muscle preparations all develop slowly and none is inhibited by atropine or antihistaminics.

Only a few suggestions have yet been made about the physiological significance of the acidic lipid-soluble substances. I suggested that 'Darmstoff' may play a part in intestinal motility[2,24] and Ambache supposes that irin is a humoral transmitter of antidromic stimulation of the trigeminal nerve. But these substances may be involved in many other physiological functions. At present we only know that they occur in the body, and as Dale said in 1933 in his third Dohme Lecture, "the discovery in artificial extract from an organ or tissue of a substance which on artificial injection produces a pharmacodynamic effect provides only a first item of presumptive evidence in support of a theory that the action of this substance plays a part in normal physiology. Much more evidence is required before we can attribute clearly defined functions to such a substance"[25].

Possible Role of Lipid-soluble Acids, particularly Phosphatidic Acids, as Carriers of Negative Charges in the Cell Membrane

I would like now to consider a biophysical aspect, which may link these substances, particularly the acidic phospholipids, to the problem of cell excitability in general. This aspect opens so many attractive vistas that it is difficult not to discuss it, although such a discussion must, at present, of necessity be highly speculative. The considerations are based on the facts that phosphatides occur in cell membranes, that acidic phospholipids have excitatory action, and on the assumption that negatively charged substances are required in cell membranes for their function.

A basic condition for cell excitability of nerves and muscles is a proper distribution of ions inside and outside the cell, which is assumed to be regulated by charged groups in the cell membrane ("fixed charge membrane", see Teorell[26]). According to this assumption cations cross the membrane by interaction with anionic groups fixed in the membrane matrix. Carboxyl groups of proteins and polyphosphates have been discussed as carriers of these negative charges, but recently Folch has directed attention to acidic phospholipids as anionic membrane constituents[27].

There are not only differences in distribution of cations and anions between the inside and outside of a cell, but also among cations themselves. There is much more potassium inside the cell than outside and the reverse is true for sodium, although the cell membrane is permeable to sodium. Therefore, an active transport mechanism has been postulated which continuously carries the sodium out of the cell against the chemical and electrical gradient. This is the so-called sodium pump. Again, acidic groups in the membrane have been made responsible for the carrier function. These carriers must combine specifically with sodium and not with potassium, or to a much lesser degree. The process has been pictured as follows. The sodium carrier, which is supposed to be a lipid-soluble anion, is formed inside the membrane, where it combines with sodium. This complex then crosses the membrane and at the outside the sodium is delivered, possibly because the carrier is destroyed or altered in such a way as to lose excess negative charge[28]. The following two facts suggest that acidic phospholipids have a stronger affinity for sodium than for potassium. (1) According to Teunissen and Bungenberg de Jong[29] lecithin, which probably contained acidic phospolipids, forms coacervates with sodium more readily than with potassium. (2) Polyphosphates have a stronger affinity for sodium than for potassium[30] and their acidic groups are the same as those of phosphatidic acids. The assumption that phosphatidic acids may be responsible for the carrier function would enable us to form an idea of how the formation and destruction of the carrier could be brought about. By splitting off the choline from a lecithin molecule at the inside of the cell membrane the phosphatidic acid would be formed and become available to combine with sodium. The complex would then diffuse to the outside. Here re-esterification would occur and this would entail blockage of the net negative charge and the liberation of the sodium.

The general ion flux and active transport so far discussed are resting conditions, which must be fulfilled for the cell to be excitable. Excitation itself is again caused by cation movements, this time going in the opposite direction, that is, with the concentration gradient. Sodium moves in and potassium out. Here again, the negatively charged membrane constituents are assumed to be involved[26] and thus phosphatidic acids may be involved in excitation as well.

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IDENTIFICATION OF ANTHOCYANIDINS, LEUCO-ANTHOCYANINS AND 2:3-DIHYDROFLAVONOLS IN PLANT TISSUES

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THE widespread distribution in plant tissues of leuco-anthocyanins yielding cyanidin (II, R = OH) and delphinidin (I, R = OH) was demonstrated by Bate-Smith[1], using paper chromatography for the identification of the anthocyanidins formed. In those tissues examined from among a large number of plant species, Bate-Smith found that leuco-compounds yielding cyanidin, and to a lesser extent delphinidin, predominate, while other patterns of hydroxylation were almost conspicuously absent. Pelargonidin (III, R = OH) has, for example, thus far been obtained only from the hot hydrochloric acid treatment of the reduction product of acetylated aromadendrin (2:3-dihydrokæmpferol) by Hillis[2].

The anthocyanidin, 3:7:8:3′:4′-pentahydroxyflavylium chloride, generated from the naturally occurring flavane-3:4-diol, melacacidin (from the heartwood of *Acacia melanoxylon*), by King and Bottomley[3], differs from those above in that in nucleus *A* the 8- in place of the 5-position is hydroxylated.

A number of plants also contain flavonoid structures in which the 7-position only is hydroxylated in nucleus *A*; for example, robinetin, 2:3-dihydrorobinetin, fisetin, fustin, butin, butein, liquiritigenin and 7:4′-dihydroxyflavonol. Some of these are present in very minor proportion in the two economically most important vegetable tanning materials, namely, black wattle or 'mimosa' extract from the bark of *Acacia mollissima*, and quebracho extract

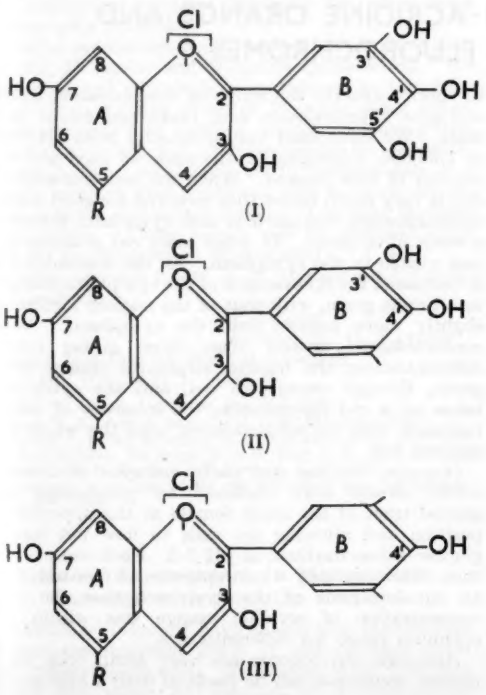

Table 1

	$\lambda_{max.}$ (mμ)	R_F in solvent system: 90 per cent formic acid/3 N hydrochloric acid (1:1)	R_F in solvent system: Water/acetic acid/conc. hydrochloric acid (10:30:3)
Delphinidin	555	0·11	0·29
Cyanidin	545	0·22	0·50
Pelargonidin	530	0·33	0·71
Robinetinidin	532	0·26	0·57
Fisetinidin	525	0·43	0·73
3:7:4′-Trihydroxyflavylium chloride	485	0·00	0·95
3:7:8:3′:4′-Pentahydroxyflavylium chloride	540	0·30	0·55

derived from the heartwood of *Schinopsis lorentzii*[4]. The polyphenolic fractions of both give resorcinol in high yield from alkali fusions[5]. From this it is evident that chromatographic identification of anthocyanidins corresponding to (I), (II) and (III), but with the 5-position unhydroxylated, is of importance.

Synthetic robinetinidin chloride or 3:7:3′:4′:5′-pentahydroxyflavylium chloride (I, R = H)[6], synthetic fisetinidin chloride or 3:7:3′:4′-tetrahydroxyflavylium chloride (II, R = H)[7], and synthetic 3:7:4′-trihydroxyflavylium chloride (III, R = H)[8], together with delphinidin, cyanidin and pelargonidin, were examined by means of paper chromatography, and the spots obtained also examined in the spectrophotometer directly on the paper, by the method of Bradfield and Flood[9]. Chromatograms were run in a constant-temperature room at 21° C. (Table 1).

The 'Forestal solvent' mainly used by Bate-Smith[1] (water/acetic acid/conc. hydrochloric acid, 10:30:3 v/v) was unsatisfactory for differentiating between pelargonidin (R_F = 0·71) and fisetinidin chlorides (R_F = 0·73). Their absorption maxima are close together (530 and 525 mμ, respectively) and their appearance on paper chromatograms very similar. A new solvent mixture consisting of 90 per cent formic acid and 3 N hydrochloric acid (1:1 v/v) differentiated these most effectively (R_F = 0·33 and 0·43, respectively) and gave good resolution of other constituents. 3:7:4′-Trihydroxyflavylium chloride remained at the origin in this solvent system, but moved with the solvent front in the 'Forestal solvent'. Robinetinidin chloride is again better separated from cyanidin and pelargonidin chlorides in the 'Forestal solvent' (R_F = 0·57, 0·50 and 0·71, respectively) than in the new formic/3 N hydrochloric acid mixture (R_F = 0·26, 0·22 and 0·33, respectively).

3:7:8:3′:4′-Pentahydroxyflavylium chloride generated from *Acacia melanoxylon* showed similar R_F to robinetinidin in both solvent systems (see Table 1), but differs from the latter in its absorption maximum, and may further be distinguished by the abnormally large shift in its absorption maximum in the presence of 0·2 per cent aluminium chloride in an ethanolic solution of hydrochloric acid[10], a method due to Geissman, Jorgenson and Harborne[11].

Anthocyanidins unhydroxylated in the 5-position have been generated by Freudenberg and Roux[6] from

2 : 3-dihydrorobinetin (found in *Robinia pseudacacia*[12]) by its easy quantitative hydrogenation with platinum oxide in methanol solution to give 7 : 3′ : 4′ : 5′-tetrahydroxyflavane-3 : 4-diol, followed by hydrochloric acid/propanol treatment[13] of the product under pressure to yield robinetinidin chloride (I, R = H). Fustin (2 : 3-dihydrofisetin) from *Rhus succedanea*[14] undergoes the same conversions, finally yielding fisetinidin chloride (II, R = H). The synthetic flavane-3 : 4-diols obtained in both instances by the reduction of the corresponding 2 : 3-dihydroflavonols are crystalline, in contrast to that occurring naturally, for example, melacacidin[3], and that obtained by the reduction of taxifolin (2 : 3-dihydroquercetin) with sodium borohydride[15], both of which are non-crystalline.

Sodium borohydride usually gives side-reactions during reduction of dihydroflavonols in aqueous and ethanolic solutions, but nevertheless affords an easy direct method of rapidly establishing the probable presence of 2 : 3-dihydroflavonols in polyphenolic mixtures, in the absence of leuco-anthocyanins of similar hydroxylation pattern. Thus the methanolic extract of the heartwood of *Grevillea robusta* contains no leuco-compound, but when preceded by a 5-min. reduction with sodium borohydride in aqueous medium, robinetinidin chloride results from treatment with hydrochloric acid.

Quebracho extract ('ordinary'-unsulphited) affords two anthocyanidins from hydrochloric acid/propanol treatment under pressure. The predominant one is easily observed as a light red spot on paper chromatograms, having an absorption maximum (523 mμ) and R_F values (0·43 in formic acid/hydrochloric acid and 0·73 in water/acetic acid/hydrochloric acid). Comparison of these values with those of fisetinidin in Table 1 ($\lambda_{max.}$ = 525 mμ and R_F = 0·43 and 0·73, respectively) indicates that a leuco-anthocyanin or leuco-anthocyanidin yielding fisetinidin is present in the heartwood of *Schinopsis lorentzii*. Similarly, the heartwood of the black wattle tree (*Acacia mollissima*) contains a monomeric leuco-anthocyan(id)in which yields fisetinidin chloride on treatment with hydrochloric acid[16].

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NEW OBSERVATIONS WITH ACRIDINE ORANGE AND PRIMULIN AS VITAL FLUOROCHROMES

Induced Fluorescence with Acridine Orange in Nematode Embryology

ACRIDINE orange was used as a vital fluorochrome by Strugger[1] for demonstrating living trypanosomes in the blood. He found that the trypanosomes fluoresced green, but made no mention of any polychromatic fluorescence by which intracellular structures can be differentiated. However, Wagner[2] has described differential fluorescence in *Trypanosoma brucei* using this dye. De Bruyn *et al.*[3] have shown that diaminoacridine compounds have an affinity *in vivo* for intranuclear deoxyribonucleoproteins. They claim that these compounds reveal the presence of ribonucleoproteins in the nucleoli but not in the cytoplasm. Armstrong[4] has recently demonstrated that, under controlled conditions of *p*H and concentration, acridine orange differentiates between deoxy- and ribonucleic acids in fixed tissues. He found that, with ultra-violet excitation, deoxyribonucleic acid fluoresced greenish-yellow, whereas ribonucleic acid showed up red.

While examining suspensions of living cells treated with acridine orange (Colour Index No. 788), we have found that, apart from nuclear structures fluorescing a bright green, certain cytoplasmic organellæ appear red. Also, in actively dividing cells the cytoplasm fluoresces red. This occurs over a limited range of concentration of the dye. It is not possible, however, to specify exactly the range of concentration which will give differentiation with maximum colour contrast. We have used values ranging from 1/10,000 to 1/30,000, depending on the material used and the number of cells present. When the concentration of dye is very much below that required for good colour differentiation, the nucleus and cytoplasm fluoresce a weak olive green. In some cases red granules are just visible in the cytoplasm. As the concentration is increased, the fluorescence of the cytoplasm changes to a bright green, with that of the nuclear structures slightly more intense than the cytoplasm. With concentrations greater than those giving colour differentiation, the nuclear structures change from green, through orange, to red, and the cytoplasm takes on a red fluorescence, the intensity of which increases with the concentration until the whole cell appears red.

Oogonia, oocytes and early embryos of *Litomosoides carinii* were obtained by puncturing the genital tract of the adult female at the appropriate position and allowing the cells to flow out into a glucose–saline medium, at *p*H 7·3. Each sample was then taken up into a micropipette and mixed with an equal volume of the dye, such that the final concentration of acridine orange was within the optimum range for differentiation.

Although the oogonia are very small cells, their unclear structures can be resolved with a high-power

objective, and exhibit a strong apple-green fluorescence. The cytoplasm fluoresces a faint reddish colour and contains bright red granules. In the growth zone of the ovary, the nucleoli take on a red fluorescence, whereas the other nuclear structures remain green. With larger oocytes the red fluorescence of the cytoplasm increases in intensity and many of the proliferating cytoplasmic granules fluoresce a strong red colour. In the fully developed oocytes, the appearances are the same except that the nucleoli fluoresce green.

In the one- and two-cell stages the colours of the cytoplasm, cytoplasmic granules and nuclear structures are similar to those of the fully developed oocyte. In the four-cell stage, however, the red fluorescence of the two smaller cells is stronger than the other two. With successively later stages of cleavage, the red fluorescence of the cytoplasm is gradually reduced in intensity. The nuclear structures continue to exhibit a strong green fluorescence and the red fluorescence of the cytoplasmic inclusions stands out more and more clearly against the diminishing intensity of the red cytoplasm. In the multicell stages the outer edges of many cells in contact with the perivitelline fluid fluoresce strongly red, in contrast to the weaker fluorescence of the remainder of the cytoplasm; relatively large intercellular bodies, fluorescing a bright red, are present in these stages. Eventually the red fluorescence of the cytoplasm disappears until only the nuclei exhibit their characteristic green colour and a few cytoplasmic granules appear red. In certain parts of the microfilaria, an intercellular substance exhibits a strong red fluorescence. This substance may originate from the red intercellular bodies of the multicell stages. The distribution of red fluorescence in the cytoplasm of the cells studied corresponds closely to the absorption picture obtained by ultra-violet micrography (2749 A.).

Similar studies are being carried out on *Dirofilaria immitis*, *D. repens* and *Nippostrongylus muris*. We have observed mitosis from metaphase to telophase occurring in a living ovum of *N. muris*, after differential staining with acridine orange, indicating that this is a true vital stain. Similar studies on spermatogenesis in these nematodes are in progress and it is already evident that treatment with acridine orange offers a quick and simple method of making chromosome counts. These results will be reported more fully on the completion of this study.

Thanks are due to Mr. J. T. Hopper for his technical assistance.

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Induced Fluorescence in Mammalian Gametes with Acridine Orange

Previous workers[1-3] have shown that mammalian spermatozoa fluoresce green or red in ultra-violet light after supra-vital treatment with acridine orange, but make no mention of polychromatic fluorescence in individual cells. We find, however, that fresh living spermatozoa of a number of mammalian species, when treated with a suitable concentration of acridine orange (G. T. Gurr) and examined under a conventional light microscope with ultra-violet dark-ground illumination, display the following colours: nucleus, bright apple green; acrosome, bright red where it extends beyond the nucleus and yellowish-green or yellow where it overlaps the nucleus; tail, a lighter green than the nucleus. Differential fluorescence of the acrosome is shown particularly well with spermatozoa of rodents, in which this structure is large, and we have obtained striking results with spermatozoa of the guinea pig, hamster, rat, mouse, cotton rat, field vole and gerbil. Similar differentiation, though less pronounced, is seen in spermatozoa of the rabbit and bull, in which the acrosome is smaller; but it has not been detected in spermatozoa of man, trout, sea urchin or honey bee. Human spermatozoa fluoresce either green, yellowish-green or red; actively motile spermatozoa of each colour may be seen simultaneously, and we are therefore unable to support Van Duijn's conclusion[3] that only dead spermatozoa fluoresce red. In the non-mammalian species examined, the spermatozoon nucleus fluoresced bright green and other structures were barely distinguishable.

In order to obtain maximum colour differentiation we have varied the concentration of dye, for different kinds and concentrations of spermatozoa, from about one part in 10,000 to one in 50,000. Within this range, and at suitable *p*H, spermatozoa remain active for a considerable time. With less dye there is no red fluorescence and spermatozoa fluoresce green or blue. At greater concentrations the dye is highly toxic and all spermatozoa fluoresce orange-red. Within the range *p*H 5·2–8·2, the differential fluorescence is relatively independent of hydrogen-ion concentration, but is shown best at the more alkaline levels. It is, however, evidently dependent upon the integrity of the acrosome, for an increasing number of spermatozoa fail to show red fluorescence in this structure during storage *in vitro* or in the female genital tract. In the spermatozoa of some species this loss of fluorescence is followed by detachment of the acrosome from the head. We believe, therefore, that loss of potential red fluorescence in the acrosome may be associated with functional impairment of the spermatozoon, although it does not necessarily indicate the death of the cell.

We have also used induced fluorescence with acridine orange to study mammalian spermatogenesis and fertilization. In smears of fresh rodent testes, nuclei fluoresce bright green, the cytoplasm faint green and developing acrosomes and many cellular inclusions bright red. Differentiation of the developing acrosome corresponds closely to that obtained with the periodic acid – Schiff reaction[4]. We also find that the developing acrosome shows marked absorption of ultra-violet light at a wave-length of 2749 A. In rat and mouse eggs the zona pellucida fluoresces faint blue, the cytoplasm contains many red inclusions, the maturation spindles appear as non-fluorescent areas in the cytoplasm, the pronuclei remain poorly differentiated and the chromosomes show very distinctly as bright green images.

It is evident from our observations that structures associated with a high concentration of deoxyribonucleic acid fluoresce bright green by the technique used. The possibility that red fluorescence indicates the presence of ribonucleic acid[5] is being investigated.

We are indebted to Mr. M. R. Young and Mr. J. T. Hopper for skilled technical assistance.

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Differentiation between Living and Dead Spermatozoa by Fluorescence Microscopy

Contrary to the observations of Stockinger[1] and of ourselves (see previous communication), Van Duijn[2] has reported that living human spermatozoa can be distinguished from dead ones by the colour of their fluorescence after treatment with acridine orange. Recently, however, we have been able to confirm Van Duijn's casual comment that a similar technique with primulin can be employed for this purpose.

In our experiments, primulin (B.D.H.) has been added to suspensions of spermatozoa at *p*H 7·2–8·2, to give a dye concentration of about one part in 30,000. For the best results the actual dye concentration should be adjusted for each sample so that optimal differentiation and minimum background fluorescence are obtained. When this is done, and the sample examined with ultra-violet dark-ground illumination, dead spermatozoa fluoresce light blue (not yellowish-green as reported by Van Duijn) and living ones remain invisible. All spermatozoa, living and dead, can be readily seen as dark-ground images when a neutral filter is substituted for the ultra-violet filter (Wratten 18*A*) normally employed. Alternatively, with a broad-band ultra-violet filter (Chance *OX*7) in place of the Wratten 18*A*, dead spermatozoa can be viewed as blue fluorescent images and living spermatozoa as red diffraction dark-ground images. A further effect is obtained by using a mixture of approximately equal amounts of primulin and rhodamin 6*G* (B.D.H.). With these dyes, and ultra-violet illumination, dead spermatozoa fluoresce light blue and living ones bright yellow. With rhodamin alone, both living and dead spermatozoa fluoresce yellow; and in living cells, but apparently not in dead ones, two granules at the base of the head are clearly differentiated.

Our preliminary observations indicate that induced fluorescence with primulin may be used for distinguishing living from dead spermatozoa in the rat, mouse, guinea pig, hamster, field vole, cotton rat, ferret, boar, bull and man. We have, however, been unable to get satisfactory results with spermatozoa of the rabbit and sea-urchin.

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BIOLOGICAL ROLE OF POTASSIUM-40

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The detection and control of intranuclear energy have instigated numerous investigations into the action of nuclear radiation upon organisms. The radiations used for experimental or therapeutic purposes, as a rule, are derived from radioisotopes which seldom occur in organisms, for example, phosphorus-32, sodium-24, etc. Moreover, owing to the relatively high doses of nuclear radiations which are usually applied, their action upon the tissues has a destructive effect.

Meanwhile, in tissues and organs of all organisms, both plants and animals, normally a number of radioactive elements are present, producing in general a weak α-, β- or γ-radiation. Among these elements first of all should be mentioned potassium-40; then come carbon-14, hydrogen-3, rubidium-87, samarium-147, uranium-238, uranium-235, thorium-232, and so on. According to the number of atoms decaying, potassium-40 occupies the first place in organisms. It may be pointed out that man during the whole of his life obtains from cosmic radiation less than 1 r., whereas from potassium-40 radiation he obtains about 10 r.

Potassium, being isolated from different sources—natural salts, rocks, tissues of organisms, etc.—has practically always a similar isotopic composition. Therefore, organisms absorbing potassium do not change their isotopic composition. In Nature, no noticeable fractionation of potassium isotopes occurs. The biological role of potassium is not clear. It is thought that potassium participates in carbohydrate and albumin metabolism of plants.

The biological function of potassium is often connected with the radioactivity of potassium-40. However, experimentally, nothing has been discovered about this. I have carried out a direct experiment concerning the question whether potassium-40, being present in a constant ratio to ordinary (natural) potassium, has any significance in the life of an organism or whether it is of no importance. *Aspergillus niger* was the organism used. It has the advantage that its whole life-cycle can be observed within a short period.

The great sensitivity of *Aspergillus niger* to potassium is well known. The culture medium consisted of:

NH_4NO_3	3·0	gm. per litre of water
$NH_4H_2PO_4$	0·500	" " "
$MgSO_4$	0·300	" " "
$ZnSO_4.7H_2O$	0·005	" " "
$FeSO_4.7H_2O$	0·030	" " "
$MnSO_4.3H_2O$	0·030	" " "
$CuCl_2.2H_2O$	0·0005	" " "
$Co(NO_3)_2.6H_2O$	0·0002	" " "
$(NH_4)_6Mo_7O_{24}.4H_2O$	0·0010	" " "
Saccharose	50·00	" " "
KCl (see the experiments)		

Table 1

Experimental series	1 Ordinary potassium	2 Potassium-40	3 Potassium-40 in radioactive equilibrium	4 Ordinary potassium	5 Potassium-39	6 Potassium-39 in radioactive equilibrium	7 Ordinary potassium	8 Without potassium	9 Ordinary potassium (without *Aspergillus niger*)
Potassium chloride content per litre of the culture medium	0·3000	0·3000	0·0030	0·0030	0·3000	18·0000	18·0000	less than 0·0001	0·3000
Amount (in cm.³) of 0·01 *N* sodium hydroxide required to neutralize acid of the nutritive solution (50 cm.³). Average of 20 experiments	20·04	24·25	37·83	40·64	13·71	30·38	22·86	17·66	13·30
Saccharose consumption (gm.) Average of 20 experiments	2·440	2·450	0·276	0·300	2·455	2·435	2·455	0·270	0
Weight of the dry mycelium (gm.). Average of 20 experiments	1·0286	1·0575	0·0327	0·0522	1·0471	1·0501	1·0507	0·0074	0

All reagents were specially freed from all foreign contaminants and repeatedly checked by spectral analysis. This was important, because *Aspergillus niger* is very sensitive to the slightest changes of concentration, in particular, of micro-elements and potassium.

We used potassium enriched in potassium-40 and potassium impoverished in potassium-40 of the following isotopic composition (per cent):

	^{39}K	^{40}K	^{41}K
Ordinary potassium	93·3	0·0119	6·7
Potassium-40	76·36	1·34	22·30
Potassium-39	99·92	0·0002	0·073

The potassium-40 content was verified also by the mass-spectrometric method and by measuring it according to the β- and γ-activity in comparison to samples of ordinary potassium. All the samples of ordinary (reagent) potassium-40 and potassium-39 were brought to spectral purity by repeated recrystallization from an alcohol–water medium, saturated with hydrochloric acid. It was thought that the introduction of potassium chloride samples would not change the content of any traces of micro-elements in this nutritive solution.

Aspergillus niger was cultivated in conical quartz flasks of volume 200 cm.³. Each flask contained 50 cm.³ of the nutritive solution prepared with doubly distilled water. Each flask was closed with a cotton-wool stopper and sterilized.

For sowing with *Aspergillus niger* a suspension of spores was prepared. About a thousand spores were introduced into each flask. The experiment was carried out in nine parallel sets, each consisting of twenty flasks containing *Aspergillus niger* in a medium of different potassium-40 composition. The area of the fungal growth was 65 cm.². All the experiments were conducted simultaneously in a thermostated room at a temperature of 33° C. ± 1° C. The nine sets of flasks contained the following: (1) 0·3000 gm. potassium chloride with ordinary potassium; (2) 0·3000 gm. potassium-40 chloride; (3) potassium-40 in radioactive equilibrium; (4) ordinary potassium in amounts similar to (3); (5) potassium-39, 0·3000 gm. as potassium chloride; (6) potassium-39 in radioactive equilibrium (18·000 gm. of potassium chloride); (7) ordinary potassium in similar amounts; (8) no potassium (according to spectral determinations, less than 1×10^{-4} per cent of potassium remained in the nutritive solution); (9) identical with (1) but without *Aspergillus niger* (see Table 1).

The experiment began on July 12 and ended four days later.

For brevity, the daily morphological observations are omitted. But direct observations of the character of the *Aspergillus niger* growth on media with different concentrations and different isotopic composition of potassium permit a preliminary conclusion concerning the absence of any action of potassium-40 radioactivity upon *Aspergillus niger*. The acid (oxalic) formed, the quantity of saccharose consumed by the fungus (according to Bertrand) and the weight of the dry mycelium (at 80° C.) were determined (see Table 1).

The results in Table 1 show that the growth of *Aspergillus niger* in sets 1, 2 and 5, containing similar amounts of potassium but differing greatly in isotopic composition and potassium-40 content, was proceeding similarly; in spite of the fact that the potassium-40 content in set 2 was 6,700 times that in set 5, the general potassium content was the same. Set 3, containing radioactive potassium in equilibrium with ordinary potassium, was completely unlike set 1, but the development of the fungus was similar to set 4, containing the same amounts in grams of ordinary potassium as set 3 (0·003 gm. of potassium chloride). In set 6, with potassium-39 in radioactive equilibrium, the fungal growth was proceeding in a very characteristic way with accelerated spore formation, etc., exactly as in the sets containing ordinary potassium at the same concentration as in set 6 (18·000 gm. of potassium chloride).

These and other results show that there is no doubt that the *Aspergillus niger* growth was proceeding in proportion to the concentration of potassium in the culture medium, regardless of its isotopic composition. The range of the potassium-40 content was in extreme cases (sets 2 and 5) 6,700 times. Thus potassium-40 radioactivity played no part in the growth of *Aspergillus niger*; only the chemical properties of potassium and its concentration were of importance.

This conclusion must probably also be extended to other organisms, or at least to both the lower and higher plants. From this it seems to follow that plants, during the process of phylogenesis, did not use natural radioactivity in their vital processes; for potassium-40 radioactivity is not responsible for any of their biological reactions or processes. Maybe animal organisms, possessing a neuromuscular tissue, containing most of the potassium, react differently to potassium-40 radioactivity. This may be decided by experiments on the perfusion of solutions containing potassium-40 through the isolated heart of an animal which we are carrying out.

LETTERS TO THE EDITORS

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Significance of Oligosaccharide Intermediates in Dextran Synthesis

THE recent isolation[1] of O-α-D-glucopyranosyl-(1→6)-O-α-D-glucopyranosyl-(1→2) β-D-fructofuranoside (I) from a complex mixture of oligosaccharides produced by the action of a cell-free extract of *Aspergillus niger* '152' on a sucrose–maltose mixture prompted us to examine its role in dextran synthesis, since the first step in the synthesis of dextran could be :

$$\underset{\text{(Sucrose)}}{\text{Glu-(1}\rightarrow\text{2)-Fru}} + \underset{\text{(Sucrose)}}{\text{Glu-(1}\rightarrow\text{2)-Fru}} \longrightarrow \underset{\text{(I)}}{\text{Glu-(1}\rightarrow\text{6)-Glu-(1}\rightarrow\text{2)-Fru}} + \underset{\text{(Fructose)}}{\text{Fru}}$$

It was observed that dextransucrase[2] prepared from *Betacoccus arabinosaceous* (Birmingham strain) had no action on (I) alone; but if the enzyme (0·5 c.c.) was incubated with a mixture of (I) (5 mgm.) and sucrose (10 mgm.) at 25° and *p*H 5, both these components rapidly disappeared. Paper chromatographic analysis showed the appearance of fructose and a series of oligosaccharides, which had R_F values less than the trisaccharide (I) in a solvent containing butanol, ethanol, water and ammonia (40 : 12 : 20 : 1) and which gave positive reactions with naphtharesorcinol[3].

Using fructose production (after 22 hr. at *p*H 5) as a criterion, the conversion of sucrose (300 mgm.) by dextransucrase was much greater in the presence of trisaccharide (I) (50 mgm.; fructose production increased 95 per cent) than with sucrose alone. In the presence of added maltose (50 mgm.; 100 mgm.) the increases in fructose production were 146 and 248 per cent respectively.

The digest containing the products from the trisaccharide (I) – sucrose mixture was adjusted to *p*H 7, heated at 60° for 15 min., cooled and freeze-dried. The mixture was dissolved in water (10 per cent w/v), streaked across sheets of Whatman No. 1 paper and irrigated with the above solvent for four days. After being dried, the strips containing the suspected tetra-, penta- and hexa-saccharide were eluted severally with water and each extract freeze-dried. The tetrasaccharide (29 mgm.) had $R_{Glucose}$ 0·21 (cf. trisaccharide (I), 0·40) in the above solvent mixture and showed an almost constant rotation after hydrolysis with 0·1 *N* hydrochloric acid at 100° for 4 min. The partial hydrolysate contained components which had the same mobilities as *iso*maltotriose and fructose. The pentasaccharide and hexasaccharide had $R_{Glucose}$ 0·12 and 0·07, respectively, and on partial hydrolysis as above gave rise to components which had the same mobilities as *iso*maltotetraose and *iso*maltopentaose, respectively, together with fructose in each case.

In the region 1,027–715 cm.$^{-1}$, trisaccharide (I) showed infra-red absorption peaks at 978(s), 919(s), 870(m), 852(m), 835(m), 803(vw), 769(m) cm.$^{-1}$. The infra-red spectra of the tetra- and penta-saccharide showed the expected similarity to that of trisaccharide (I) with decreased absorption at 870 and 852 cm.$^{-1}$ as the proportion of the fructose moiety became less. It is therefore concluded that dextransucrase acting on sucrose can use trisaccharide (I) as a receptor, but not as a substrate, to synthesize a homologous series of oligosaccharides by the addition of α-1 : 6-linked glucose residues to the glucose end of trisaccharide (I), thus :

$$\underset{\text{(Sucrose)}}{\text{Glu-(1}\rightarrow\text{2)-Fru}} + \underset{\text{(I)}}{\text{Glu-(1}\rightarrow\text{6)-Glu-(1}\rightarrow\text{2)-Fru}} \longrightarrow \underset{\text{(Tetrasaccharide)}}{\text{Glu-(1}\rightarrow\text{6)-Glu-(1}\rightarrow\text{6)-Glu-(1}\rightarrow\text{2)-Fru}} + \text{Fructose}$$

Several points of interest emerge from the above observations. Since trisaccharide (I) is not a substrate for dextransucrase, in contrast to sucrose, it is probable that higher homologues of (I) also cannot function as substrates. If this is so, then unbranched dextrans must be built up by successive transfers of single glucose units, and transfers of preformed chains are not involved. Moreover, any fructose-terminated oligosaccharide formed from an acceptor molecule such as sucrose or trisaccharide (I) would eventually lead to a dextran molecule carrying a terminal fructose residue[4] (cf. inulin and lævan). The fact that oligosaccharides do not accumulate when dextransucrase acts on sucrose alone may be due either to the operation of a single-chain mechanism[5] or to a multi-chain mechanism in which a slow initial synthesis of trisaccharide (I) is followed by a rapid polymerization to dextran. Since oligosaccharides are now shown to be formed from sucrose and trisaccharide (I), when present together in comparable amounts, it is likely that the multi-chain mechanism is operative. The results obtained with mixtures of sucrose and other acceptors (for example, methyl-α-D-glucoside) point to the same conclusion[2].

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Optical Activity of Homologous Series

THE optical activity of asymmetric molecules has frequently been used as a criterion of purity and also a means of identification of naturally occurring chemical compounds. In this laboratory we are particularly interested in the *anteiso* series of fatty acids found in natural fats[1,2]. These optically active fatty acids were recently synthesized in a high state of purity by Milburn and Truter[3] and the optical rotations of this homologous series are therefore available to test Tschugaeff's rule[4]. According to this the specific rotations of members of a homologous series are inversely proportional to the molecular weights within certain limits, and the molecular

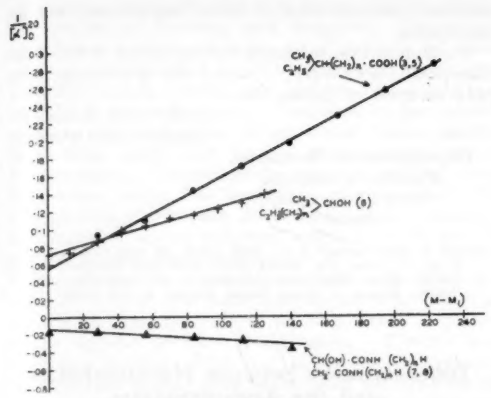

Fig. 1. Plot of $1/[\alpha]_D^{20}$ against $(M-M_1)$
$[\alpha]_D^{20}$, specific rotation at 20° C.; M, molecular weight; M_1, molecular weight of the first member of the series

rotations are constant within wide limits, that is, the molecular rotations are independent of the molecular weights.

It seems, however, that the specific rotations should be inversely proportional to the distance of the functional group from the asymmetric carbon atom, that is, inversely proportional to the difference in molecular weight between the homologue concerned and the lowest member of the series. In the case of *anteiso* acids this is 2-methylbutyric acid.

The hypothesis can be tested by plotting Milburn and Truter's[3] values of $\frac{1}{[\alpha]_D^{20}}$ against the difference in molecular weight between the homologue and 2-methylbutyric acid (Fig. 1).

When the straight line obtained in Fig. 1 is extrapolated to zero, the intercept, that is, $\frac{1}{[\alpha_1]_D^{20}}$, is 0·56. $[\alpha]_D^{20}$ of (+)-2-methylbutyric acid is thus + 17·9° (Marckwald[5] found + 16·67°). The relationship is expressed by the equation:

$$\frac{1}{[\alpha]_D^t} = (M - M_1)K_a + \frac{1}{[\alpha_1]_D^t}$$

where K_a is a constant and $[\alpha_1]_D^t$ is the specific rotation of the first member of the series.

A similar equation should apply to the molecular rotation, defined as $[M]_D^t = [\alpha]_D^t \times M$, namely,

$$\frac{1}{[M]_D^t} = \left(\frac{M - M_1}{M}\right) K_M + \frac{1}{[M_1]_D^t}$$

where $[M_1]_D^t$ is the molecular rotation of the first member of the series. That this is indeed the case is shown in Fig. 2.

Since K_M does not equal 0, Tschugaeff's contention that the molecular rotation is independent of the molecular weight cannot be true, although in some cases K_M may approximate to 0.

A series of carbinols of the type $C_2H_5.(CH_2)_n.CHOH.CH_3$ described by Pickard and Kenyon[6] provides further evidence (Figs. 1 and 2) and also shows that K_M may be negative. Finally, the diamides of malic acid[7,8] may serve as an example (Figs. 1 and 2). These have a negative rotation, but K_M is positive.

Tschugaeff observed that the lower members of a homologous series do not always adhere to his rule and deviations from the above relationships have also been found in a number of cases. In some cases, however, only the second homologue deviates to a considerable extent. This may be attributed partly to experimental error. Nevertheless it is hoped that the above relationship will be helpful in the purification and identification of optically active members of homologous series.

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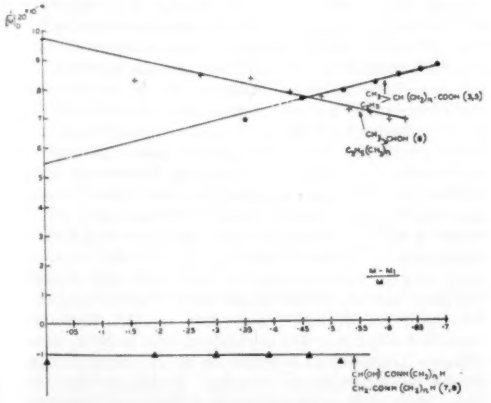

Fig. 2. Plot of $\frac{1}{[M]_D^t}$ against $\frac{M - M_1}{M}$

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Amperometric Titration of Dodecyl Pyridinium Bromide with Sodium Dodecyl Sulphate

Recently, one of us (R. T., unpublished work) found that dodecyl pyridinium bromide gives a polarographic reduction wave in 0·1 *M* sodium hydroxide solution containing 0·2 m*M* polyoxyethylene lauryl ether as a maximum suppressor, the diffusion current measured at − 1·325 V. vs. the saturated calomel electrode being proportional to the concentration of dodecyl pyridinium bromide in the range of 0·06–2·0 m*M*. The combination of this finding and the well-known fact that the reaction between cationic and anionic detergents often yields a very insoluble precipitate in aqueous solutions suggested to us the amperometric titration of dodecyl pyridinium bromide with one of the anionic detergents or vice versa. We consider the method proposed here to be much simpler and more accurate than those previously reported[1].

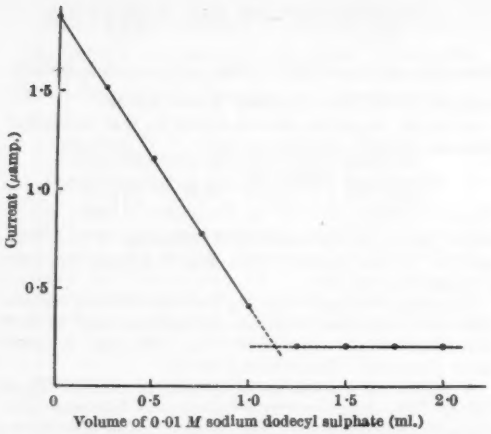

Fig. 1. Titration curve of the solution of 0·0006 *M* dodecyl pyridinium bromide with 0·01 *M* sodium dodecyl sulphate in 0·1 *M* sodium hydroxide – 0·2 m*M* polyoxyethylene lauryl ether

Solutions of dodecyl pyridinium bromide of concentration 0·1 m*M*–1·0 m*M* were titrated amperometrically at the potential of −1·325 V. *v.* saturated calomel electrode with a 2 m*M* or 10 m*M* sodium dodecyl sulphate solution in 0·1 *M* sodium hydroxide – 0·2 m*M* polyoxyethylene lauryl ether, using a dropping mercury electrode as indicator electrode. In each titration, 20 ml. of the solution containing dodecyl pyridinium bromide was run into a titration cell, and the dissolved oxygen removed by passing purified nitrogen through the solution. During the titration, the current was measured nearly 6 min. after each addition of the titration agent, because the current tended to decrease gradually and to reach the equilibrium value. This effect was observed more clearly in the vicinity of the equivalence point of the titration and seems to be due to the slowness of the velocity of reaction between dodecyl pyridinium bromide and sodium dodecyl sulphate at low concentrations.

All titration curves obtained under the conditions mentioned above were of typical *L*-type (Fig. 1), from which the equivalence points were definitely determined. The accuracy of the determination was found to be ± 0·005 m*M* in terms of the standard deviation in the concentration range of 0·1–1·0 m*M* of dodecyl pyridinium bromide.

When a relatively large excess of sodium dodecyl sulphate was added to the dodecyl pyridinium bromide solution, the precipitate formed at first began to dissolve and at the same time small polarographic waves appeared at the potentials of – 0·9 and – 1·2 V. *v.* the saturated calomel electrode. This phenomenon, however, did not interfere with the actual titration process. The titration curves gave very sharp end-points because of the extremely low solubility of the reaction product, and it was unnecessary to continue the titration to such a large excess of sodium dodecyl sulphate (see Fig. 1).

The amperometric titration of dodecyl pyridinium bromide with sodium dodecyl sulphate is accurate and rapid and has a great advantage and potentiality over other methods previously reported, especially at low concentrations of the detergents. Further study along these lines will undoubtedly widen the applicability of the amperometric titration to the accurate determination of other cationic and anionic detergents.

We should like to thank the members of the Nezu Chemical Laboratory, Tokyo, for providing very pure samples of detergents.

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Differentiation between Myrosulphatase and the Arylsulphatases

The presence in the seeds of certain Cruciferae of myrosulphatase, an enzyme capable of liberating sulphuric acid from potassium myronate (sinigrin), was first observed by Neuberg and Wagner[1]. Afterwards Neuberg and Wagner[2] claimed to have detected a similar enzyme in certain horse and rabbit tissues. These authors observed only slight hydrolysis of phenyl sulphate by horse liver suspensions and no hydrolysis of potassium myronate by mushroom arylsulphatase, and hence concluded that myrosulphatase and arylsulphatase were distinct enzymes. However, it has recently become clear[3] that there are present in Nature two types of arylsulphatase, one of which shows little affinity and activity towards phenyl-, *p*-acetylphenyl- and *p*-nitrophenyl sulphate but considerable affinity and activity towards 2-hydroxy-5-nitrophenyl sulphate (nitrocatechol sulphate). At least two enzymes of this type are now known to occur in mammalian tissues[4–6], and it was of interest to determine whether they could have been responsible for the myrosulphatase activity observed by Neuberg and Wagner[2]. We have therefore compared the activities towards potassium myronate and nitrocatechol sulphate of various mammalian liver preparations and of the myrosulphatase-rich seeds of black and white mustard (*Sinapis niger* and *S. alba*).

Fresh horse- and rabbit-liver suspensions were found to liberate approximately 2,000 μgm. sulphate/hr./gm. tissue from 0·01 *M* nitrocatechol sulphate at 38° in the presence of 0·5 *M* acetate buffer, *p*H 6·0. On the other hand, using a wide variety of experimental conditions, no myrosulphatase activity could be detected in these tissues or in acetone-dried preparations of human, rabbit and rat livers. Furthermore, although black and white mustard seeds were both found to be very active towards potassium myronate (*S. niger*, for example, liberating approximately 40,000 μgm. sulphate/hr./gm. from potassium myronate in the presence of 0·2 *M* acetate, *p*H 5·0), their activity towards nitrocatechol sulphate was negligible. Under optimal conditions and after dialysing to remove possible inhibitory ions, a partially purified extract of the seeds of *S. niger* liberated only 40 μgm. sulphate/hr./gm. dry weight from nitrocatechol sulphate. No arylsulphatase activity towards either nitrocatechol sulphate or *p*-nitrophenyl sulphate could be detected in *S. alba*. It seems clear, therefore, that myrosulphatase is a distinct enzyme.

It should be pointed out that the failure to detect myrosulphatase in mammalian tissues during the

present experiments does not necessarily invalidate the results of Neuberg and Wagner[2]. The myrosulphatase activity of horse liver claimed by these workers corresponded to a liberation of only 38 μgm. sulphate/hr./gm. tissue, and before myrosulphatase activity of this order can be confirmed, longer incubation periods and more concentrated tissue suspensions than were used in the present work would be necessary. Unfortunately, we were unable to do this, since, using the benzidine micro-method[7] for determining enzymically liberated sulphate, complete recoveries of added inorganic sulphate could not be achieved under such conditions.

The observation of arylsulphatase activity in the seeds of *S. niger* is of some interest, since no previous reports on the existence of arylsulphatase in higher plants appear to have been made. Kinetic and inhibition studies, which will be reported elsewhere, indicate that this arylsulphatase is of the type which is particularly active towards nitrocatechol sulphate.

One of us (H. B.) is grateful to the Medical Research Council for a research assistantship.

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Solanine and Related Alkaloids

In an investigation on the relation between solanine content of potato tubers and their resistance to fungal infection, crude extracts of solanine were examined chromatographically, using a modification of Curry and Powell's method[1]. The solvent was prepared as described; but after separation the organic phase was shaken up in the separating funnel and sufficient *n*-butyl alcohol added to remove any cloudiness. This mixture was not only used for development but also placed in the bottom of the tank instead of the aqueous phase. Poor results were obtained if the paper was equilibrated over the aqueous phase before development, suggesting that good separation depended on the ability of the paper to absorb some water from the developing solvent. R_F values varied from one run to another, so that it was necessary to run known compounds for comparison. The position of the alkaloids was detected with a modified Dragendorff's reagent[2].

A typical chromatogram obtained by this method is shown in Fig. 1. In all potato tissues examined, solanine was found to be accompanied by about an equal amount of a substance with very similar properties but which had an R_F value (0·37) higher than solanine (0·23) though less than the first glycoside (0·42) obtained by partial hydrolysis of solanine. Small quantities of this substance were

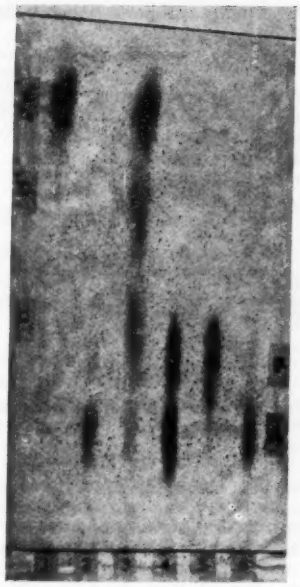

Fig. 1. Chromatogram showing separation of solanine and related compounds. (1) Solanidine; (2) and (6) solanine; (3) mixture obtained by partial hydrolysis of solanine—*A*, solanine, *C* and *D*, intermediate glycosides, *E*, solanidine; (4) 'crude solanine' from potato—*A*, solanine, *B*, α-chaconine; (5) α-chaconine

isolated by separation on cellulose columns and its properties found to agree with those of α-chaconine, first recorded in the potato by Kuhn and Löw[3], two moles of rhamnose and one of glucose being obtained by hydrolysis from each mole of glycoside.

Samples of crude 'solanine' from other sources were examined, using the method described, and were found in general to differ from the sample from potato (Table 1). These deviations were small but sufficient to suggest that a detailed investigation of these substances might yield interesting results.

Table 1. R_F Values (referred to Solanine) for 'Solanine' from Different Sources and for Demissine and Tomatine

Source	Substance 1	Substance 2
Solanum tuberosum	1·00	1·32
S. dulcamara	1·12	1·39
S. nigrum	1·08	1·32
S. demissum (demissine)	0·93	—
Lycopersicon esculentum	1·00	—
L. pimpinellifolium (tomatine)	0·93	—

The effect of sodium ions in increasing the toxicity of solanine to spores of *Fusarium caeruleum*[4] was found to be nullified in the presence of calcium ions. The concentration of calcium ions required was very

Table 2. Calcium Ion Concentration required to reduce Mortality of *F. caeruleum* Spores to 50 per cent in Veronal Buffer Solutions, *p*H 7·6, containing Solanine 1 : 16,000 and a Range of Sodium Ion Concentrations

Sodium ion concentration, *M*/100	Calcium ion concentration, *M*/100
43	0·156
33	0·092
23	0·050
13	0·017
8	0·003

low, though roughly proportional to that of the sodium ions present (Table 2).

This work will be reported in full elsewhere.

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Stimulation of Non-Specific Immunity by the 'Lipid *A*' Component of Bacterial Lipopolysaccharide

A temporary increase in resistance to infection by certain bacteria has been shown to follow the intravenous injection of minute amounts of lipopolysaccharides isolated from heterologous Gram-negative organisms[1]; 0·5 μgm. of most lipopolysaccharide preparations is an effective dose for a 20-gm. mouse. Increased resistance has also been observed following the intravenous injection of other colloidal or particulate materials, such as native dextran[2] or 'Zymosan'[3], although only when used in much larger doses, for example, 5–25 mgm. Furthermore, even with this thousand-fold difference in effective dose, the increase in resistance is less than that following bacterial lipopolysaccharide.

We have attempted to determine the component of lipopolysaccharide which is responsible for this high activity in modifying immunity, and have been guided by the extensive chemical investigations of Westphal and Lüderitz[4]. These authors have shown that mild acid hydrolysis of lipopolysaccharide leads to depolymerization of the macromolecule with the separation of insoluble lipoid material (lipid *A*), leaving degraded polysaccharide in solution. Our present investigations have shown that whereas the latter is quite unable to stimulate non-specific immunity, the isolated lipid *A* is still active when given in microgram amounts.

The lipid *A* used in these experiments was isolated from *Escherichia coli* (strain 2380) lipopolysaccharide by the method of Westphal and Lüderitz[4]. It was separated from degraded polysaccharide by repeated centrifuging and washing in distilled water. The final dried product comprised approximately 10 per cent by weight of the original material. In view of the insolubility of lipid *A* in water, various attempts were made to prepare stable suspensions suitable for intravenous administration and two alternative procedures have been found satisfactory. One method consisted of dispersing the lipid with 'Aerosol *OT*'; in the other, the lipid was dissolved in chloroform, to which was added hot ethanol and boiling distilled water, the organic solvents being afterwards evaporated at 100°. We are indebted to Dr. Nina Chouroun for suggesting this latter procedure. Lipid *A* preparations contained less than 0·1 per cent lipopolysaccharide as assessed by a hæmagglutination-inhibition test[5], and produced no obvious toxic signs in mice injected with up to 700 μgm.

Table 1. The Effect of Lipid *A* given Intravenously 48 hr. before an Intraperitoneal Challenge with *Esch. coli* in Mice

Material injected intravenously 48 hr. before challenge	No. of organisms in challenge		
	10^4	10^5	10^6
50 μgm. lipid *A*	1/10*	—	—
10 μgm. lipid *A*	—	3/10	—
50 μgm. lipid *A* + 35 μgm. 'Aerosol *OT*'	—	—	2/10
35 μgm. 'Aerosol *OT*' alone	—	—	8/10
Nil	6/10	8/10	9/10

* Number of deaths/number of animals injected

To examine lipid *A* for protective activity, mice were injected intravenously with various doses contained in not more than 0·1 ml. After 24–48 hr., the animals were challenged intraperitoneally with either a natural pathogen (*Salmonella typhimurium* strain *S2/446*) or with *Esch. coli* (strain 145) administered in 1·75 per cent hog mucin (Wilson, 1701)[3]. Increased resistance to *Esch. coli* infection has been demonstrated repeatedly following the injection of lipid *A* suspensions, either with or without 'Aerosol *OT*'. Three typical experiments are shown in Table 1. A significant response has been obtained with as little as 8 μgm. lipid *A*, but not with 2 μgm. Increasing the dose of lipid *A* beyond 50 μgm. has not improved the degree of protection, which has always been less than that obtained with the parent lipopolysaccharide. Conversely, with *Salm. typhimurium* infections, lipid *A* has appeared to be somewhat more effective than lipopolysaccharide. In these experiments no great improvement in numbers of survivors was seen; but prolongation in the mean survival period was observed. Table 2 shows two representative experiments in which the differences in mean survival times are significant at the 1·5 per cent and 4·5 per cent levels respectively. These two values when considered together are highly significant ($P < 0·1$ per cent).

These results indicate that lipid *A* is about one-tenth as active as lipopolysaccharide on an equal weight basis or one-hundredth as active in terms of lipid content. Westphal and Lüderitz have suggested[4] that lipid *A* is the component responsible for the pyrogenicity of lipopolysaccharide, although the separation by hydrolysis and dispersion of the lipid on casein involved a fifty-fold loss in pyrogenic activity. The superiority of the intact lipopolysaccharide over lipid *A* in these phenomena is possibly due to effective dispersion of lipid throughout the macromolecule.

Lipid *A* is readily taken up by the reticulo-endothelial system, as are many other lipids when injected intravenously. Furthermore, it produces a rapid activation of this group of cells, demonstrable

Table 2. The Effect of Lipid *A* given Intravenously 24–48 hr. before injecting *Salm. typhimurium* (100 organisms) Intraperitoneally in Mice

Lipid *A* injected intravenously	No. of animals in group	Periods of survival (days)	Mean time to death (days)
50 μgm., 24 hr. before challenge	15	8, 9, 9, 11, 11, 11, 13, 17, 26, 26, *S*, *S*, *S*, *S*, *S*	14
Nil	15	4, 4, 5, 5, 5, 6, 6, 7, 8, 10, 13, 17, *S*, *S*, *S*	7·5
60 μgm., 48 hr. before challenge	10	4, 5, 6, 17, 30, 35, 37, *S*, *S*, *S*	19
Nil	10	4, 5, 6, 7, 8 9, 11, 12, 14, *S*	8·5

S = survived more than 42 days

both histologically and by the rate of uptake of phosphorus-32 - labelled lipopolysaccharide[6] *in vivo*. These changes, which will be described more fully elsewhere, probably determine in large part the stimulation of non-specific immunity.

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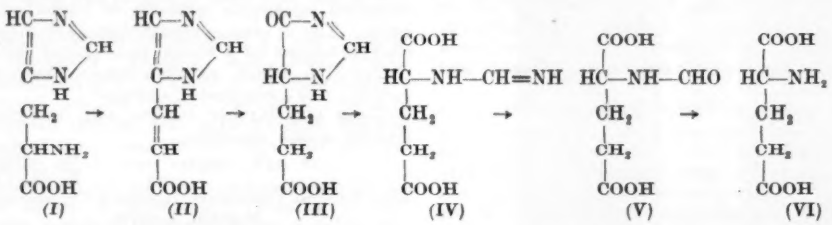
Formylglutamate as one of the Intermediates of Histidine Metabolism

There have been many studies[1-5] on the metabolism of histidine. According to the theory now accepted generally, the anaerobic metabolic pathway of this amino-acid to glutamic acid is as follows:



Of the distinct intermediate products, only urocanic acid (II)[2,3] and formamidinoglutaric acid (IV)[7] have so far been isolated and identified. We have examined this metabolic sequence by isolation and identification of the individual intermediates by paper partition chromatography.

First, histidine was incubated with mouse liver homogenate in phosphate buffer of *p*H 8·0 at 38° C., and at intervals of 6 hr. an aliquot was taken out from the reaction mixture, which, after being deproteinized, was developed on Tōyō filter paper No. 50 with *n*-butanol/acetic acid/water (4 : 1 : 2) (ascending method). Two spots were detected at R_F 0·75 and 0·59, with diazo reagent giving red coloration. The substance of R_F 0·75 was shown to be urocanic acid, as these two substances had the same R_F values in several solvent systems. The substance of R_F 0·59 could not be identified. At R_F 0·35 another spot was detected with ninhydrin, giving a violet coloration. This substance was separated into two spots (*Fig. 1*) by developing with pyridine/*n*-butanol (2 : 1) and *n*-butanol/ethanol (4 : 1) by a continuous ascending method, one of which showed the same R_F values as those of formylglutamic acid in several solvent systems (Table 1), thus indicating their identity. Another spot was shown to be glutamic acid, giving the same R_F value with several solvent systems as those of a synthetic sample.

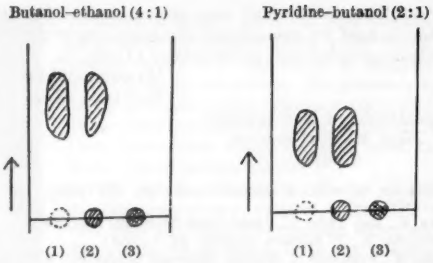


Fig. 1. Separation of the R_F 0·35 substance by continuous ascending paper partition chromatography. (1) Formyl-L-glutamic acid; (2) the R_F 0·35 substance; (3) L-glutamic acid

These products found as intermediates were examined by paper partition chromatography to ascertain whether or not they can yield the sequence of reaction products with liver homogenate. First, urocanic acid was incubated with mouse liver homogenate and treated in the same manner as described for histidine; the products were formylglutamic acid and glutamic acid and an unknown diazo-positive substance having R_F 0·59 in *n*-butanol/acetic acid/water (4 : 1 : 2). Then formylglutamic acid was incubated in nearly the same manner as described above, and it was found that it can be easily degraded in formic acid and glutamic acid.

Following the procedure used by Borek *et al.* in the isolation of formamidinoglutaric acid, we incubated histidine with cat liver homogenate for 24 hr. at 38° C. After the reaction mixture had been deproteinized, the reaction product was purified by precipitating twice with mercuric acetate and adsorb-

Table 1

Compound	I	II	III	IV	V
Separated substance	0·08	0·37	0·05	0·29	0·35
Formyl-L-glutamic acid	0·09	0·36	0·05	0·29	0·36

I. Amyl alcohol/formic acid (4 : 1), saturated with water.
II. Acetic acid/*iso*propanol (3 : 17).
III. Pyridine/*n*-butanol (2 : 1).
IV. Phenol/10 per cent ammonium hydroxide (4 : 1).
V. *n*-Butanol/acetic acid/water (4 : 1 : 2).

Table 2

Compound	Analysis: nitrogen (%)		R_F value I	II	III	IV	V
Substance isolated	8·32	−7·4*	0·08	0·36	0·06	0·29	0·36
Formylglutamic acid	8·13	−7·8*	0·08	0·36	0·05	0·29	0·38

I. *n*-Butanol/ethanol (4 : 1).
II. Acetic acid/*iso*propanol (3 : 17).
III. Pyridine/*n*-butanol (2 : 1).
IV. Phenol/10 per cent ammonium hydroxide (4 : 1).
V. *n*-Butanol/acetic acid/water (4 : 1 : 2).
* 2 per cent solution in 1 *N* hydrochloric acid.

ing on 'Permutit', and was shown to be formyl-L-glutamic acid by elementary analysis, paper partition chromatography and polarimetry (Table 2).

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Cytopathogenicity of Rinderpest Virus in Tissue Culture

Takematsu and Morimoto[1] have reported cultivation of lapinized rinderpest virus in roller-tube cultures of rabbit lymph node, spleen and bone marrow; but details are not available to us, and it is not known if cytopathological effects were observed. In this laboratory, we have found that the Kabete '*O*' strain of virulent rinderpest virus multiplies in monolayers of bovine embryonic kidney cells and produces characteristic cytological changes. In addition, kidney-passaged virus destroys bovine fibroblasts grown from embryonic skin-muscle tissue and prepubertal testis.

Cell monolayers in Carrel flasks, flat bottles or Petri dishes were prepared from all tissues, using standard trypsinization procedures[2]. Skin-muscle and testis fragments were also embedded in a chicken-plasma clot in stationary tubes. The media used included either lactalbumin hydrolysate (0·5 per cent) or bovine amniotic fluid (90 per cent) as basic constituents, fluid changes being carried out every three or four days. Fixed and stained coverslip preparations[3] of infected and healthy monolayers were examined frequently during several passages.

The initial inoculum was a 10 per cent infected bovine spleen suspension, equivalent to approximately 10^6 *ID*50 virus per ml. The next three passages were made on well-established monolayers, using fluids harvested three or seven days after inoculation of the cultures. In later passages, the virus and 5 per cent suspensions of trypsinized cells were incubated together for 30 min. at 35° C., diluted tenfold with medium and dispensed into the final vessels. The procedure did not interfere with the temporary formation of a complete cell sheet and the virus induced earlier and more extensive cytopathological changes.

Seven passages in kidney cells were carried out; preliminary titrations in cattle, of fluids withdrawn at intervals, indicated that maximal titres of 10^4 *ID*50/ml. were attained after six to seven days incubation, representing at the sixth passage a $10^{-13\cdot6}$ dilution of the original inoculum. Minimal cytopathological changes were evident in a first tissue-culture passage at three days when stained preparations were examined. At the seventh passage, changes were evident at three to four days in unstained cultures and the monolayer was destroyed by the twelfth day. Undiluted, seven-day fluids from the fourth to seventh kidney passages were cytopathogenic for fibroblasts after two to four days. The identity of the cytopathological agent was established by its infectivity for rinderpest-susceptible cattle and by the neutralization of the effect by sera from rinderpest-immune cattle, goats, hamsters and rabbits. Fluids from cultures inoculated with non-cytopathogenic serum–virus mixtures did not infect cattle susceptible to rinderpest.

In both kidney epithelium and fibroblast cultures the cytopathological changes began focally and seemed to extend primarily by contiguity from cell to cell. With dilute inocula, plaque-like lesions, 1–3 mm. in diameter, developed; but secondary plaques were few or absent, even without a plasma or agar overlay. Kidney cells and fibroblasts showed rounding or irregular shrinkage, increased refractility and detachment from the glass; such cells, stained with Giemsa, were often deeply basophilic and showed irregular fragmentation. Numerous syncytial aggregates were also formed, these containing up to about two hundred nuclei, with masses of deeply eosinophilic granules in the cytoplasm. They later contracted and finally became detached into the fluid. Nuclear changes, particularly in small syncytia, included the marked clumping of chromatin, especially on the nuclear membrane, accompanied by the appearance of numerous, intensely eosinophilic granules or the development of homogeneous type *B* inclusions with a clear halo[4]. The multinucleate formations were similar to those recently observed[5] in lesions of stratified squamous epithelia of rinderpest-infected cattle. The *in vitro* cytopathological changes suggest that rinderpest virus should be classified with Enders[6] Group III*b*, which includes monkey kidney agents, measles and presumably mumps[7].

These and further studies will be published in greater detail elsewhere.

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Specific Precipitin Reactions with the Viruses of Foot-and-Mouth Disease and Vesicular Stomatitis

Precipitin reactions in gels, described as early as 1905 by Bechhold[1], have been used by Oudin[2], Ouchterlony[3] and others to demonstrate the presence of several components in antigens previously thought to be homogeneous. The work of Oudin and Ouchterlony has created new interest in this type of reaction, and their techniques have been applied recently to the study of the viruses of influenza[4], the pox group[5] and foot-and-mouth disease[6]. The results of this work indicate the value of the gel diffusion techniques for identifying virus types and for the study of the number of antigens in virus preparations.

We have confirmed Bodon's observation[6] with the three types (*O*, *A* and *C*) of the virus of foot-and-

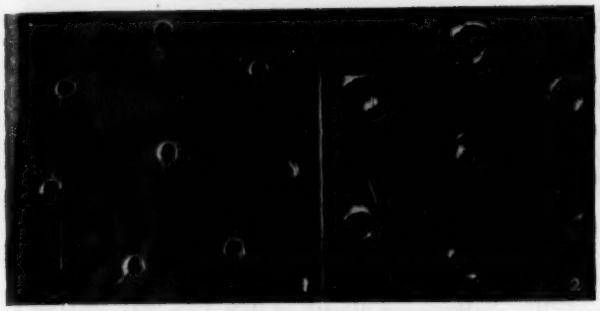

Fig. 1. Reaction of guinea pig vesicular fluid (*C*) in centre cup with antisera to all seven known types of the virus of foot-and-mouth disease (*A*, *O*, *C*, *S.A.T.*1, *S.A.T.*2, *S.A.T.*3 and Asia 1) arranged clockwise with *A* in top cup

Fig. 2. Reaction of cattle vesicular fluid (*S.A.T.*2) in centre cup with guinea pig antisera containing antibodies to *S.A.T.*1 (cups 3 and 4), *S.A.T.*2 (cups 2 and 5) and *S.A.T.*3 (cups 1 and 6). The cups are numbered clockwise with cup 1 at top

mouth disease which he used and have extended it to include the other four immunological types (*S.A.T.*1, 2 and 3 and Asia 1). The reaction is for all practical purposes type-specific (Figs. 1 and 2), although slight cross-reaction with heterotypic antisera has been observed in a few isolated instances. When cross-reaction occurs, the precipitin line is just discernible after four to five days, whereas the specific reaction can be clearly seen after one to two days.

The reaction is also type-specific for the virus of vesicular stomatitis ("Indiana" and "New Jersey" immunological types). As there is no cross-reaction between these and the various types of the virus of foot-and-mouth disease, the agar diffusion method can be added to those already available for the differentiation of the two viruses (Fig. 3).

The concentration of the preparations is an important factor in determining whether or not precipitation occurs. Whereas infective fluids (for example, guinea pig or cattle vesicular fluid or virus grown in culture) of titre 10^7–10^8 *ID*50/ml. give a strong reaction, a tenfold dilution is often sufficient to prevent formation of a precipitin line. Suitable concentration of virus extracts with lower titres, for example by precipitation with half-saturated ammonium sulphate at 4° C., has enabled us to obtain precipitin lines with virus extracts which did not show a reaction at their original strength. In general, type-specific hyper-immune guinea pig sera have been used as the source of antibody, but lines have been obtained with sera taken from convalescent cattle.

Our results differ from those of Bodon in one important respect, namely, that two lines are usually obtained when any of the virus types reacts with its homotypic antiserum. The lines on the plates are about 1 mm. apart, whereas the separation in the tubes is greater (see Fig. 4). Although it is well established that preparations of the virus of foot-and-mouth disease contain two distinct particles[7–9], the question as to whether each line is due to a different antigen must await further experiments in view of Jennings's[10] observation that one antigen may produce two lines. It is hoped that application of the immuno-electrophoretic technique of Grabar and Williams[11] will throw light on this question. The relation between the antigenic mass and the appearance of a precipitin line is also being examined.

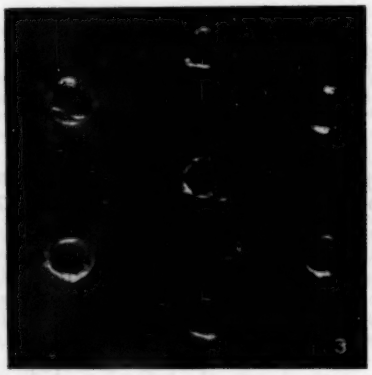

Fig. 3. Reaction of vesicular stomatitis virus (Indiana) in centre cup with guinea pig antisera containing antibodies to two types of vesicular stomatitis virus (New Jersey, cup 2, and Indiana, cup 3) and four types of foot-and-mouth disease virus (*S.A.T.*3, cup 1; *O*, cup 4; *A*, cup 5; *C*, cup 6). The cups are numbered as in Fig. 2

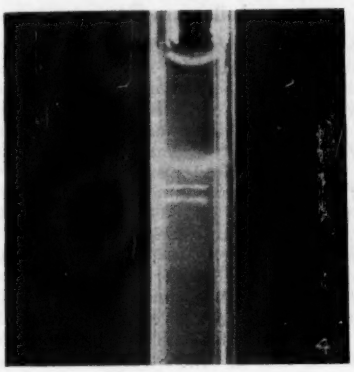

Fig. 4. Reaction in tubes of guinea pig vesicular fluid (*O*) against homotypic guinea pig antiserum. The two precipitin lines are more clearly separated than on the plates (Figs. 1 and 2)

In our experiments we have used both the double-diffusion method in tubes (Fig. 4) first described by Oakley and Fulthorpe[12] in 1953 and the Ouchterlony[2] plate technique adapted to a micro-scale. The plate technique, which we have found to be more convenient, is described below. A 1·5 per cent solution of washed agar in 0·1 *M* barbitone buffer (*p*H 8·2) or physiological saline, with 1 : 10,000 merthiolate as preservative, is poured to a depth of 3 mm. into a Petri dish. After the agar has set, holes 2 mm. in diameter and 8–10 mm. apart are cut with a Pasteur pipette and the agar cylinders removed by suction. The antigen and antiserum are then added to the appropriate holes and the plate held at 25° C. It was found that 20–30 μl. of infective vesicular fluid and the same volume of homotypic antiserum, each added as two or three aliquots of 10 μl., was sufficient to give faint lines overnight and distinct lines in 48 hr.

Our attention has been directed recently to observations by Moosbrugger, Spuhler and Meyer

(communication to Dr. I. A. Galloway), who have used the technique for the titration of antibody in the sera of cattle convalescent from infection with foot-and-mouth disease.

We wish to thank our colleagues, particularly Dr. J. B. Brooksby, for supplies of materials.

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5-Hydroxytryptamine in Acute Inflammation

In the course of examining inflammatory exudate for substances capable of acting as mediators of increased capillary permeability it was found that in pleural exudates collected from rats within an hour of intrapleural injection of 0·1 ml. turpentine there were significant amounts of 5-hydroxytryptamine. Since then, similar exudate collected 30 min. after injury has been found to contain 1–3 μgm. 5-hydroxytryptamine/ml. One hour after injection this value has fallen to 0·2 μgm./ml. or less. 30-min. exudates contain less than 0·5 μgm. of histamine.

5-Hydroxytryptamine is generally known as a vaso-constrictor; but in view of the above finding it was tested for its effect on capillary permeability in the rat. Using the intravenous trypan blue technique it was found that in concentrations of 100 μgm./ml. or more 5-hydroxytryptamine constricted vessels but that it caused marked increase in capillary permeability between 10 and 1 μgm./ml. Thus in the rat 5-hydroxytryptamine is about 100 times more potent in this respect and on a weight basis than histamine. In addition, Rowley and Benditt[3] observed that œdema followed the injection of 5-hydroxytryptamine (1 μgm./ml.) into the paws of rats. These authors have suggested that liberation of 5-hydroxytryptamine may be the cause of œdema following injection of egg-white into rats, and that mast cells might be the source of the 5-hydroxytryptamine so released.

During experiments to be published elsewhere it was observed that the precursor of permeability-increasing globulins in plasma could be activated by incubation with isolated, washed mitochondria. It was therefore decided to test a similar system for the development of 5-hydroxytryptamine activity. Platelet-free exudate collected 24 hr. after intrapleural injection of turpentine is free of 5-hydroxytryptamine activity. 2 ml. of such resolving exudate was incubated for 30 min. at 37° with the washed mitochondria, isolated by differential centrifugation[4], from one pair of rat lungs.

As a result of this procedure the exudate acquired 5-hydroxytryptamine-like activity to the average extent of 1 μgm./ml. Saline similarly incubated with mitochondria failed to develop 5-hydroxytryptamine activity.

The 5-hydroxytryptamine-like activity in the incubated exudate was assayed on a piece of isolated guinea pig ileum suspended in oxygenated Tyrode solution. It was unaffected by the addition of mepyramine maleate (1 μgm./ml.) to the bath, and was abolished by the similar addition of 0·1 μgm. lysergic acid. The effect was also abolished by adding large amounts of 5-hydroxytryptamine to the bath prior to testing the exudate.

Resolving pleural exudate from rats contains an inhibitor of capillary permeability[1] similar to that described in guinea pig serum by Miles and Wilhelm[5]. This inhibitor suppresses the action of permeability-increasing globulins on blood vessels but is ineffective against peptides and histamine. However, it almost completely abolishes the action of 5-hydroxytryptamine on capillary permeability but fails to influence the effect of it on guinea pig ileum.

The action of low concentrations of 5-hydroxytryptamine on capillary permeability, its presence in adequate amounts in early inflammatory exudate, its liberation by interaction of plasma, platelets and cell constituents and its inhibition by a relatively specific depressant of capillary permeability in the blood all suggest that 5-hydroxytryptamine may help to mediate vascular changes in the earliest phases of inflammation. Its presence in exudates may also indicate that it is partly responsible for the pain of inflammation, as 5-hydroxytryptamine causes pain in low concentrations[6].

Finally, it is of some interest that a similar *in vitro* system, a rough approximation to the condition of tissue injury, should lead simultaneously to blood clotting, activation of a globulin system controlling capillary permeability and to release of 5-hydroxytryptamine.

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Egg Yolk-Coagulating Enzyme in the Semen and Cowper's Gland of the Goat

Glycine egg yolk and egg yolk citrate, prepared by mixing equal volumes of 4 per cent glycine and egg yolk and 3·6 per cent sodium citrate and egg yolk, were used in an attempt to extend the volume of ejaculated goat semen and to preserve the motility and fertility of the spermatozoa. With semen diluted twenty times it was found that most of the initially motile spermatozoa remained so for three days in both the diluents at 3° C.; thereafter the number of live sperm and degree of motility declined precipitously. Extinction of spermatozoal life in glycine egg yolk was always preceded by coagulation of the diluent. The following

observations show that this coagulation is due to the presence of an enzyme in goat semen. The enzyme is present in plasma and requires activation by calcium; hence absence or delay of coagulation of medium containing citrate. Further, when spermatozoa are freed from this enzyme, by washing with normal saline, viability is greatly improved.

(1) Washed spermatozoa remain vigorously motile for 6 and 9 days in egg yolk citrate and glycine egg yolk respectively at 3° C., whereas when neat semen was used the life of sperms was 3 days only. Whereas extinction of the spermatozoal life was preceded by complete coagulation or curdling of glycine egg yolk, no such physical change took place either in the other diluent egg yolk citrate or in control tubes containing glycine egg yolk only. With 'sperm free-plasma' complete coagulation of glycine egg yolk took place within 2 days at 3° C. and in about 10 hr. when incubated at 37° C. Coagulation, however, did not take place at 3° C. when such plasma was added to glycine egg yolk after being treated for 2 min. in a boiling water-bath.

Later it was found that coagulation also took place when, instead of glycine egg yolk, a mixture of equal volumes of water and egg yolk is used. In all subsequent experiments egg yolk and water mixed in the proportion of 4 : 1 was used as the substrate.

Since seminal plasma is made up of the secretions of the seminal vesicle, prostate and Cowper's gland, it is obvious that the source of this enzyme must be one of these glands. These organs were dissected immediately after slaughter of adult goats and were extracted with cold distilled water by triturating them separately in mortars with sand; for every gram of the material 10 ml. of water was used. The extracted material was then centrifuged for 20 min.

(2) When 0·5 ml. of the supernatant was added to 2 ml. of substrate it was found that coagulation of egg yolk took place only with Cowper's gland extract and not with the extracts of the other two glands. The time required for coagulation varied between 24 and 30 hr. at 3° C. and between 2 and 3 hr. at 37° C. Aliquots of Cowper's gland extract when used after being kept in a boiling water-bath for 2 min. was always ineffective in bringing about coagulation. Extracts preserved in a refrigerator with a drop of chloroform in them have been found to retain the coagulating activity in full for more than 6 weeks. The extract has been found to be incapable of bringing about coagulation of either egg white, or mixture of egg white and egg yolk, or milk. Egg yolk therefore appears to be the specific substrate of this coagulating enzyme. Extracts made out of the Cowper's gland obtained from castrated goats are conspicuous in not possessing any coagulating activity. It appears, therefore, that the elaboration of the egg yolk-coagulating enzyme in Cowper's gland is dependent on the male hormone testosterone. The coagulating effect is also absent in extracts made out of Cowper's gland obtained from an adult ram. The time required for coagulation of egg yolk, either by seminal plasma or Cowper's gland extract, is prolonged when citrate or oxalate is added to the medium.

Investigations to study the various characteristics of this enzyme are in progress.

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Sensitivity of the Mouse Mamma to Urinary Mammotrophin

It has recently been shown that mammotrophic hormones are present in the urine of an appreciable number of pre- and post-menopausal women[1]. These hormones are capable of stimulating growth in the mammary glands of weanling male mice. It has been found, however, that different strains of mice react unequally to the same known stimulus and some fail to respond at all.

Many strains of laboratory mice, including the well-known *A*, *C57 Bl.*, *C_3H*, *DBA*, *BALB* and *LAB Grey*, have been investigated for mammary sensitivity. Ten male weanlings were used from each strain; they were injected twice daily for five days with a human urine proved to be active in a reacting strain of mouse. On the sixth day the animals were killed and skinned. The pelts were fixed and afterwards stained. The anterior six glands were dissected off, cleared and mounted.

Reacting glands are characterized by bulbous swellings (called 'clubs') at the ends of the ducts. The average number of clubs per gland is determined for all the glands in a given strain of mouse. This 'club count' is considered to be a measure of the degree of the reaction. No urine was considered 'active' unless on injection it stimulated our standard reactive mouse and produced an average club count of 3·5 per gland or more.

Contrary to expectation, it was found that the ability to react to mammotrophins is an uncommon property among mice. So far, only one inbred strain (*A_3G*) and one non-inbred strain (*S.A.S.* 3) have been found to possess it to a significant degree. A full account of this work is in course of preparation for publication elsewhere.

These striking variations in mammary reactivity are of great practical significance, as the estimation of mammotrophic potency of the urine is becoming an important pre-operative test in cases of human breast cancer treated by hypophysectomy.

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Reversibility of Fluorescence by Annealing

Some time ago, Ewles *et al.*[1] found that a large number of colourless inorganic solids show, on excitation by light of wave-length shorter than 330 mμ, a bluish fluorescence (and phosphorescence) when wetted by distilled water.

While studying the fluorescence of various minerals, I found that a bluish-greenish fluorescence shown by many of them when excited by ultra-violet light of wave-length 365 mμ is also due to adsorbed water. The fluorescence does not appear after the samples have been strongly heated for a short time, but it returns when they are either kept for months exposed to the air or when they are wetted. Rather surprisingly, the fluorescence is also regenerated when the strongly heated samples are heated again to a less degree, an effect which can be referred to as 'fluorescence, reversible by annealing'.

This effect takes place only when the second heating is performed in an open receptacle, not when the samples are heated in sealed tubes; it does, however, occur when pellets of wetted asbestos are included in the tubes, thus showing that the fluorescence is due to water.

The effect is shown by all feldspars with greenish fluorescence that I could examine, by wollastonite from Monte Baldo and, especially strikingly, by a bluish anhydrite from Bleiberg, Carinthia, the bluish-greenish fluorescence of which turns to yellow after strong heating and back to green again on renewed heating.

A detailed account was presented to the Austrian Academy of Sciences on June 14. The reversible fluorescence has recently also been found in a number of zeolites, especially in desmine from Iceland, and some chemicals of varying degree of purity: sulphates of the alkali and alkaline earth elements, carbonates of the same, oxides of the alkaline earth elements; not, however, in sodium and potassium chlorides and calcium fluoride and nitrates. In no case was phosphorescence observed.

What happens is evidently this: on strongly heating the samples, all water is driven out, fluorescence is absent. During cooling in open air, water vapour condenses on the surface without giving rise to fluorescence. When, however, a certain energy of activation is supplied by renewed heating, the water molecules are bound more strongly to the surface (active sites? impurities?) than by mere surface adsorption, and this state, intermediate between surface adsorption and water of crystallization, is fluorescent.

With a wider variation of experimental conditions (degree and duration of heating, wave-length of excitation) the effect will perhaps be found to be still more widely distributed. A quantitative study of the reversible fluorescence might throw some light on the adsorption of vapours on solid surfaces and on the structure of the latter.

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Electron Diffraction Investigation and Magnetic Measurements on Nickel (II) Bisacetylacetone

Some nickel (II) complexes are paramagnetic, whereas others are diamagnetic. These complexes are classified as tetrahedral or planar on the basis of magnetic measurements with the aid of Pauling's theory[1] relating the geometric configuration of ligands, various arrangements of electrons in orbitals, and the resulting magnetic moments. Nickel (II) bisacetylacetone is known to be paramagnetic[2], and for this sole reason is believed to be an example of a tetra-co-ordinated complex having a tetrahedral structure. A more direct method of investigation has recently been undertaken by Bullen[3], who, using X-ray diffraction, showed that there are three nickel atoms in an asymmetric unit, the three atoms being very nearly collinear. He argues that with trinuclear molecules the possibility of octahedral co-ordination

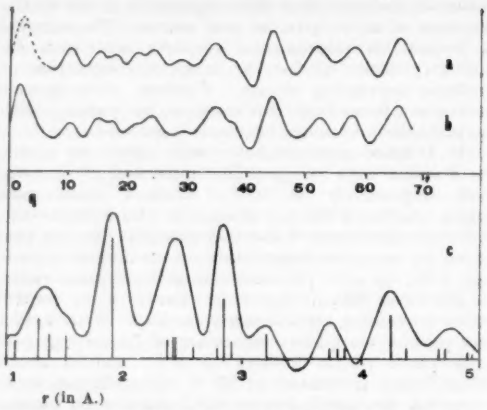

Fig. 1. The visual intensity curve (*a*), the theoretical intensity curve (*b*), and the radial distribution curve (*c*). The atomic distances of the best model are indicated by the abscissæ of the vertical lines, the heights of which are drawn in proportion to Z_iZ_j/r_{ij}

of the nickel atoms must be taken into account, and that it is not simply a choice between tetrahedral and square co-ordination. We considered it desirable to elucidate the structure of a free molecule of this compound, and have undertaken its investigation by electron diffraction.

The apparatus used was that already reported by one of us and collaborators[4]. The sample was vaporized at about 170° C. The diffraction camera had an r^3-sector. The visual observation of diffraction patterns was made up to $q = 70$.

The radial distribution function obtained from the experimental intensity curve is shown in Fig. 1. The four prominent peaks at 1·90, 2·84, 3·20 and 4·25 A. were assigned to Ni—O^1, Ni—C^1, Ni—C^2 and Ni—C^4 distances, respectively; here oxygen and carbon atoms are numbered by superscripts as in O^1—$C^1(C^4H_3)$—C^2H—$C^3(C^5H_3)$—O^2. Each of these peaks is an isolated peak and/or corresponds to an atomic distance involving a great scattering power, and therefore gives a reliable value for the respective separation.

In order to calculate the theoretical intensity, the following assumptions were made. In the first place, the central nickel atom and the heavy atoms of each acetylacetone molecule lie on a plane and the ligand molecule is symmetrical across a plane perpendicular to the molecular plane. Secondly, C—H distances were assumed to be equal to 1·08 A., the contributions from other distances involving a hydrogen atom being disregarded. With these assumptions and the four distances mentioned, the complete molecular configuration can be determined provided that three additional parameters are known for planar and perpendicular models in which the two molecular planes of ligands are coplanar and perpendicular to each other, respectively. An angle, $\angle O^1NiO^2$, and two distances, C^1—C^3 and C^1—C^4, were chosen for the three parameters. The theoretical intensity curves were calculated for about sixty models having molecular parameters varying in the following ranges: $\angle O^1NiO^2 = 84$–$110°$, C^1—$C^3 = 1{\cdot}32$–$1{\cdot}57$ A., C^1—$C^4 = 1{\cdot}51$–$1{\cdot}54$ A. The two distances, Ni—C^3 and Ni—C^4, were also varied to a certain extent, since the peaks assigned to them are not so pronounced as those due to the Ni—O^1 and

Ni—C^1 distances, and for the perpendicular model the distances between atoms belonging to different ligands might possibly affect the shapes of the peaks in question.

It was found that no perpendicular models, including that having the tetrahedral arrangement of oxygen atoms, gave a theoretical intensity curve in agreement with the observed one. On the other hand, a coplanar model having the four oxygen atoms located approximately at the corners of a square could reproduce the experimental results, the values for the structural parameters being as follows: $\angle O^1NiO^2 = 94 \pm 4°$, $C^1—C^2 = 1{\cdot}37 \pm 0{\cdot}05$ A., $C^1—O^1 = 1{\cdot}30 \pm 0{\cdot}06$ A., $C^1—C^4 = 1{\cdot}51–1{\cdot}54$ A. (The planar configuration of this nickel complex was reported at a meeting of the Chemical Society of Japan held in November 1952.) The theoretical intensity curve for the best model is compared with the experimental curve in Fig. 1.

Apparently, the present conclusion contradicts Pauling's presumption of tetrahedral configuration. Since, however, the magnetic measurement was made at ordinary temperature, whereas the sample under investigation was heated in the electron diffraction experiment, it was thought worth while to investigate the possible change of the magnetic moment with temperature. Therefore, susceptibility measurements were made by use of a Gouy magnetic balance[5] over the temperature range 19°–200° C. Allowing for the diamagnetism of the chelated groups and assuming the validity of the Curie law, the magnetic moment of the nickel of this complex in the solid state was found to be independent of temperature and equal to 3·15–3·22 Bohr magnetons, corresponding to two unpaired electrons in the nickel atom. A possible qualitative explanation is afforded by the experiment by Bullen, since a nickel atom in octahedral complex can display paramagnetism.

Further studies were made of X-ray powder photographs. The nickel complex was recrystallized several times from alcohol and was sublimed *in vacuo* to obtain green anhydrous nickel bisacetylacetone. On heating at about 170° C., the green colour was slightly tinged with yellow. These two samples differing in colour showed different Debye–Scherrer patterns, suggesting that a change was taking place in the crystal structure. Comparison of the Debye–Scherrer photographs with the crystal data of Bullen suggests that his sample was the high-temperature modification of the complex used in our investigation. Although the structure of a free molecule of this compound is determined, more comprehensive study is required before one can make a choice between the tetrahedral and the square (or octahedral) co-ordination in the crystal.

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Use of Ferrous Sulphate Solutions for X-Ray Dosimetry

The absolute yield of ferric ions produced on irradiation with cobalt-60 γ-rays and fast electrons of aerated solutions, 1–10 mM in ferrous ion and 0·1–2 N in sulphuric acid, has been measured by various methods and a 'G-value' of 15·6 ± 0·4 ferric ions per 100 eV. absorbed is now well established[1]. Less information is available on the yield of this system with X-rays of 250 keV. and lower energy, which are commonly used in studies in radiation chemistry. Ionization methods of measurement of the energy absorbed from such radiation have limited accuracy, owing to the difficulty of correcting for the photoelectric absorption in the sulphur atoms present, to uncertainties in the parameters used in computing dose, and because of geometrical considerations. To minimize photoelectric absorption, it is obvious that the sulphuric acid content of the system should be as low as possible; but the use of solutions less than 0·1 N in sulphuric acid is not recommended, this being the lower limit of the range of independence of yield on acid concentration[2].

It is possible that, in the future, calorimetric or other more direct methods will be devised for measurement of energy absorbed; meanwhile, additional relevant information can be derived from a study of the relative yields of the products of irradiation, assuming a knowledge of the mechanism of the reaction, which is now well established. For example, we have measured the ratio of the yield of molecular hydrogen to that of ferric ion in solutions initially saturated with oxygen, with three types of radiation: (i) cobalt-60 γ-rays, (ii) unfiltered radiation from a Siemens 250-kV. constant-potential therapy unit, (iii) unfiltered radiation from a Philips 50-kV. contact therapy unit.

The hydrogen and ferric ion yields were measured in the same solution in every case. The 'Pyrex' reaction vessels contained 10–14 c.c. of solution and were fitted with break seals for removal of the gaseous products. They were pre-irradiated with about 100,000 rads of cobalt-60 γ-radiation before use. After filling with an oxygen-saturated solution about 4 mM in ferrous ions and 0·8 N in sulphuric acid, they were sealed quickly with a minimum gas space. The irradiation produced 2·5–2·8 mM/l. of ferric ion, together with 10–15 μM/l. of hydrogen; afterwards, the dissolved gases were removed by refluxing the solution under a trap containing powdered solid carbon dioxide, and transferred with a Toepler pump to a gas manifold, of known total internal volume, fitted with a McLeod gauge. In this the hydrogen was analysed by combustion on platinum with the excess oxygen which was always present, and the resulting water vapour was condensed in a 'dry ice' – acetone mixture. A mechanically operated piston was fitted to the McLeod gauge reservoir for precise adjustment of the mercury-level. The accuracy of each reading was estimated at ± 0·25 mm. and with the minimum observed pressure decrease of 60 mm. the maximum resulting error was ± 0·8 per cent. Estimated uncertainties in the calibration of the gas manifold were ± 0·5 per cent; and the total estimated error in the hydrogen measurement was thus ± 1·3 per cent.

After removal of hydrogen, the contents of the reaction vessel, with several rinsings, were transferred to a volumetric flask and diluted to a concentration suitable for analysis by absorption measurements[2]

with a Unicam spectrophotometer at 304 mμ. The results, which show the anticipated increase of the hydrogen–ferric ion ratio with increasing ion density of the radiation, are given in Table 1.

Table 1. Ratio of Hydrogen and Ferric Ion Yields in Oxygenated Solutions

Type of radiation	$G(H_2)/G(Fe^{3+})$
Cobalt-60 γ-rays	0·0258 ± 0·0008
250-kV. X-rays	0·0305 ± 0·0009
50-kV. peak X-rays	0·0327 ± 0·0014

It is known that the hydrogen yield under constant irradiation increases slightly as the system becomes depleted of oxygen[2], but conditions were maintained constant throughout the measurements, so that no significant error was introduced on this account. It was estimated that the increase in hydrogen yield over a complete irradiation was of the order of 2 per cent under the experimental conditions.

Following the generally accepted mechanism for this oxidation in aerated solution, we have:

$$H_2O \rightarrow aH_2 + bH_2O_2 + cH + dOH$$

For this overall decomposition of the water, the stoichiometry demands that:

$$G_{-H_2O} = 2G_{H_2} + G_H = 2G_{H_2O_2} + G_{OH} \quad (1)$$

Of these products, hydrogen is inert, one molecule of hydrogen peroxide oxidizes two ferrous ions, one hydroxyl radical one ferrous ion, and one hydrogen atom, after conversion to HO_2 by dissolved oxygen, three. The yield of ferric ions is thus:

$$\begin{aligned} G_{Fe^{3+}} &= 2G_{H_2O_2} + G_{OH} + 3G_H \\ &= 2G_{H_2} + 4G_H \\ &= 4G_{-H_2O} - 6G_{H_2}, \text{ from (1) above} \end{aligned}$$

From this result, writing $G_{H_2}/G_{Fe^{3+}} = R$, we have:

$$G_{Fe^{3+}} = 4G_{-H_2O}/(1 + 6R)$$

In order to compute the appropriate yields of ferric ion from the results in Table 1, information is therefore necessary concerning G_{-H_2O} as a function of radiation quality. This is a less sensitive function of ion density than is the ferric ion yield, varying only from 4·5 ± 0·1 for cobalt-60 γ-rays to 3·5 ± 0·1 for the radiations from the $^{10}B(n,\alpha)^7Li$ process, and information as to its behaviour over this wide region of ion density is now available (Barr and Schuler, Brookhaven National Laboratory, New York, private communication). From this it may be predicted that the value of G_{-H_2O} appropriate to 250-kV. X-rays will be 4·4 ± 0·2, the corresponding quantity for 50-kV. peak X-rays being 4·2 ± 0·2. Using these figures, we derive:

$G_{Fe^{3+}}$ (250-kV. X-rays)	14·9 ± 0·8
$G_{Fe^{3+}}$ (50-kV. peak X-rays)	14·0 ± 0·8

The yields of hydrogen are thus 0·45 ± 0·02 and 0·46 ± 0·02 molecules per 100 eV. for the two types of radiation respectively, that with cobalt-60 γ-rays being 0·40 ± 0·01. With electrons of initial energy less than 40 keV., the yield of ferric ions may be expected to be a sensitive function of this energy, and the integral yield obtained with soft X-radiation must therefore be specific to the irradiation conditions, particularly to the degree of filtration of the primary beam.

We would like to record our gratitude to the Radiotherapy Department of the Western General Hospital, Edinburgh, for allowing us to use its Siemens 250-kV. X-ray sets, to the Physics Department of this Hospital for its co-operation in the irradiations, and to the Edinburgh Royal Infirmary for the loan of its Philips 50-kV. contact therapy unit.

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Optical Properties of 'Cellophane'

In *Nature* of November 10, p. 1072, Dr. E. F. Fahy and Prof. M. A. MacConaill discussed this subject.

Some years ago, I investigated the use of 'Cellophane' for a device which was to rotate the plane of polarization of light and, among the specimens examined, I came across a variety which in double thickness behaved like a quarter-wave retardation plate. Subsequent investigation proved that the material was in fact birefringent, and by stacking several thicknesses (interleaved with a highly refractive oil), refractive indices of 1·588 and 1·594 were measured on a Rayner gemmological refractometer. This material, under the proprietary name of 'Styrafoil', is being manufactured by Messrs. BX Plastics, Ltd., in a variety of thicknesses for use as an interlayer between electrical transformer windings.

The 'half-mil' thickness consistently caused a retardation of one-eighth of a wave of sodium light; this led me to build a polarization step-wedge of the material as an alternative device to the usual quartz or selenite wedge used for compensation on the polarizing microscope. It was satisfactory for general use, and of course much cheaper than the mineral variety.

If stacked strips of 'Styrafoil' are used for building a wedge, they must be cut from the same area of the sheet. This is because while the vibration directions of 'Styrafoil' are consistently at 90°, there is a tendency for them to twist about 5° per ft. of foil along the length of the roll. This is not of very great consequence, and leads to the Newton colour scale not being as brightly coloured as it would otherwise be.

From the foregoing, it would seem that the manufacture of commercial material does involve precise control of thickness, and that, in the case of 'Styrafoil', there seems no question but that the colour in polarized light is a thickness and not a surface property.

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A Case of Hæmoglobin *J* in an Indonesian Family

Since the discovery of the abnormal human hæmoglobin *H* by Rigas *et al.*[1], three other abnormal hæmoglobin types, *I* [2], *J* [3] and *K* [4], have been found to migrate faster in paper electrophoresis than normal adult hæmoglobin at a *p*H of 8·6. These four hæmoglobins can be distinguished by their differences in electrophoretic mobility at *p*H 8·6 ($H = I > J > K > A$), while the difference between hæmoglobin-*H* and

Table 1. Some Hæmatological Data of a Family with Two Members possessing the Abnormal Hæmoglobin *J*

	Father K	Mother K	D.K.	J.K.	A.K.	M.K.
Age	33	31	6	4	3	1
Hæmoglobin (gm., per cent)	17·2	13·8	12·1	11·4	12·7	11·6
R.B.C. millions/cu. mm.	6·5	5·2	4·5	4·0	5·1	4·7
Retic. (per cent)	1·1	1·1	1·7	2·0	1·9	1·6
W.B.C. (per cu. mm.)	6,700	11,300	6,400	8,100	5,500	10,800
Osmotic fragility (per cent saline)	0·48–0·40	0·47–0·39	0·46–0·37	0·48–0·40	0·46–0·36	0·47–0·34
Target cells	0	0	0	0	0	0
Indirect serumbilirubin (mgm. per cent)	0·9	1·1	0·8	0·4	0·5	0·7
Splenomegaly	absent	absent	absent	absent	absent	absent
Type of hæmoglobin	*A*	*A+J*	*A*	*A+J*	*A*	*A*

hæmoglobin-*I* is demonstrable when they are compared on paper electrophoresis at *p*H 6·5 [3].

The subject of this report is the first description of a case of hæmoglobin-*J* in an Indonesian family. The abnormal component was found in a young female of Javanese extraction and her four-year-old daughter. The husband, a native of the island of Ambon in Indonesia, and the three other children were quite normal. The clinical and hæmatological data of the members of this family are given in Table 1. Compared with normal values no significant deviations were found for the two individuals who are heterozygous for the abnormal component.

Paper electrophoretic examinations of the hæmoglobin at different *p*H's (Fig. 1) revealed a component of normal hæmoglobin and a component with electrophoretic mobility faster than normal hæmoglobin *A*. The best separation was obtained using a buffer at *p*H 7·9 and ionic strength of 0·06. Also with the moving-boundary electrophoresis at *p*H 6·5 and ionic strength 0·1 the separation into two components was complete. The proportions were found to be 65 per cent hæmoglobin-*A* and 35 per cent abnormal hæmoglobin with an electrophoretic mobility of about 2×10^{-5} cm.^{2} sec.$^{-1}$ volt^{-1}.

Using a spectrophotometric alkali denaturation method[4] no alkali-resistant fraction was found. The hæmoglobin of our case was further studied by cation exchange chromatography on 'Amberlite *IRC*-50' using the procedure of Huisman and Prins[5]. Even with different buffer solutions varying in *p*H from 5·7 to 8·5 and in sodium ion concentration of 0·05–0·35 no separation into two components could be obtained.

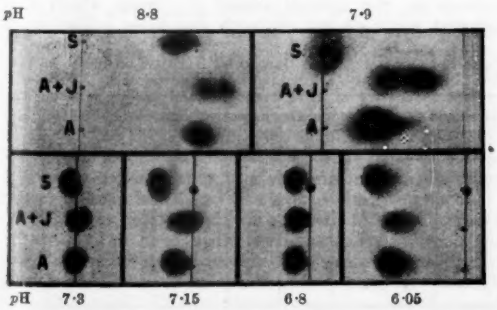

Fig. 1

Comparative studies with hæmoglobin *H* (Dr. D. A. Rigas, Portland, Ore.), hæmoglobin *I* (Dr. D. L. Rucknagel, Durham, N.C.), hæmoglobin *J* (Dr. H. A. Itano, Bethesda, Md.) and hæmoglobin *K* (Dr. R. Cabannes, Alger) revealed that our abnormal hæmoglobin was identical with hæmoglobin-*J*.

This investigation has been supported by a grant of the Netherlands Organization for Pure Research (Z.W.O.). We are much indebted to Drs. Rigas, Rucknagel, Itano and Cabannes for the comparative studies.

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Emergence of Larvæ from Sealed Cysts of the Potato Root Eelworm, *Heterodera rostochiensis* Wollenweber

Investigation of the distribution of hatching among the eggs contained in the cysts of the potato root eelworm showed that hatching is not random; eggs near the cyst wall tend to hatch sooner than eggs nearer the centre of the egg mass[1]. It also appeared that the position of eggs in relation to either of the two natural openings, the neck and vulva, was without influence on the hatching distribution: further work has confirmed this finding, for it has now been shown that sealing either of the openings has no detectable effect on the distribution. Moreover, emergence from cysts with only one effective opening appears to take place as rapidly as from normal cysts.

The neck or vulval apertures were sealed with rubber solution or with 39° C. paraffin wax. Controls were made up of cysts the walls of which were covered to a roughly similar extent with either of the two sealing materials. A group of untreated cysts was also included. The results of four hatching experiments using a single-cyst technique[2], each with four lots of twenty cysts, are presented in Table 1, geometric means being used since they give a better idea of the population. Analyses of variance, using the log transformation necessitated by the nature of the data[3], gave values for *p*, the probability, which were

Table 1. Emergence of Larvæ from Sealed and Untreated Cysts: Geometric Mean Values based on the Emergence from Twenty Individual Cysts

Treatment	Experiment 1	2	3	4
Cysts with the neck sealed	56·5	16·0	6·4	27·2
Cysts with the vulva sealed	62·1	16·8	3·1	17·2
Control cysts with wall part sealed	51·4	15·6	3·9	18·1
Untreated controls	68·1	21·4	6·1	26·5
Duration of experiment (days after beginning of stimulation)	16	9	9	10

greater than 0·2 for all four experiments; clearly there are no differences in emergence as a result of the treatments—nor was any shown during the course of the experiments.

Little is known about the period between the hatching of a larva from its egg and its emergence from one of the two openings. These results show that either of the cyst openings is as effective as the other, since there was no difference between neck- and vulva-sealed cysts, and that a single opening is perfectly adequate for hatching to occur at the 'normal' rate. Since during these experiments almost a hundred larvæ sometimes emerged from a single opening during 24 hr., this latter finding is most surprising. Evidently competition to emerge among hatched larvæ cannot be so great as was thought; moreover, it is clear that larvæ do not emerge from the cyst as a result of random movement.

This work was supported by a grant from the Agricultural Research Council and was carried out in the Department of Zoology, King's College, Newcastle on Tyne, under the supervision of Dr. C. Ellenby.

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Resistance of the Spiny Boll Worm to Endrin in Israel

In 1956 very poor control of the spiny boll worm (*Earias insulana* Boisd.) on cotton was obtained in the Beith She'an area in Israel with endrin, although in previous years this compound gave excellent control and is still highly effective in other parts of the country. No published report has come to our knowledge of endrin resistance of the spiny boll worm. However, it has been claimed that the cotton boll weevil has developed resistance to this compound[1].

Larvæ of the spiny boll worm were collected from cotton bolls from four localities in the Beith She'an and adjacent areas. Larvæ from Sachnin in the coastal plain, a place where unirrigated cotton was grown for the first time this year and has been treated only once with endrin, as well as larvæ from untreated okra (*Hibiscus esculentus*) plants served for comparison.

The larvæ were exposed in groups of ten to endrin deposits (from acetone solutions; 1 gm./sq.m.; 1 day old) in closed Petri dishes. Only results for last-stage larvæ are reported, since in the untreated control dishes there occurred some mortality in earlier stages. However, results with all stages tested showed the same trend. Under the test conditions, there was no lethal gaseous effect of endrin during 18 hr.

In Table 1, experiments repeated on different days are summarized. After an exposure time of, for example, 5 hr., larvæ from four localities in the Beith She'an area were much less affected by endrin than those collected from the other sources. The observations do not permit of measurement of the exact degree of resistance which has obviously developed.

We wish to record that E. Rivnay (private communication), too, has suggested that the spiny boll worm may have developed resistance to endrin and has found this to be the case for adult moths tested.

Our thanks are due to A. Ben Shmuel for technical help.

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Table 1. Mortality of Last-Stage Larvæ of the Spiny Boll Worm, exposed to 1 gm./sq.m. Endrin Deposits, 1 Day Old, on Petri Dishes *t*, 30 – 31° C.

Source	Previous endrin treatment	No. of larvæ tested	% Dead and paralysed larvæ after exposure indicated (hr.)										
			½	1	1½	2	2½	3	3½	4	4½	5	18*
Beith She'an Valley and adjacent area:													
Doshen	Sprayed systematically for the past three years at about 14-day intervals	57	0	5	10	23	21	25	28	28	33	35	53
Gevath		115	1	3	6	15	17	17	22	25	29	32	47
Chavat Shmuel		24	0	0	4	17	21	21	21	21	21	21	59
Beith Hashita		29	0	0	0	7	10	17	17	17	21	17	38
Other sources:													
Sachnin	One spray only	97	0	16	34	62	72	74	72	76	80	84	97
Okra plants	Untreated	50	20	40	64	74	86	90	94	96	98	98	100

* No mortality in controls from all localities.

Pulsating Aeration of Microbial Cultures

Two difficulties are frequently encountered when it is desired to grow pathogenic bacteria with active aeration, namely, foaming and wetting of the exhaust filter. Chemical or mechanical foam-breaking and heating systems can be used to avoid these problems but have many disadvantages. I have used them mainly on large-scale equipment[1,2]. However, it was found that a basically different approach had to be used for ordinary laboratory equipment. Since the method which has been developed may have wide applications, it will be described below.

The basic principle (see Fig. 1) involves the use of only one sterile filter (*a*), and air is forced back and forth through this. To start the cycle, air is sucked through the filter into the glass growth vessel (*g*) by a temporary vacuum above the culture. As this causes the glass bead valve (*d*) to close, the air must pass out into the culture from below. The big bubbles so formed are caught in an inverted beaker (*i*) which has a small hole drilled in its bottom. From this a continuous stream of small bubbles goes to the surface, where foam collects. Following the pulse of ingoing air, a water-ejector sucks air and foam out of the growth vessel through the valve (*d*). The foam collects in the conical vessel (*c*), from which the exhaust air goes out through the filter. The next

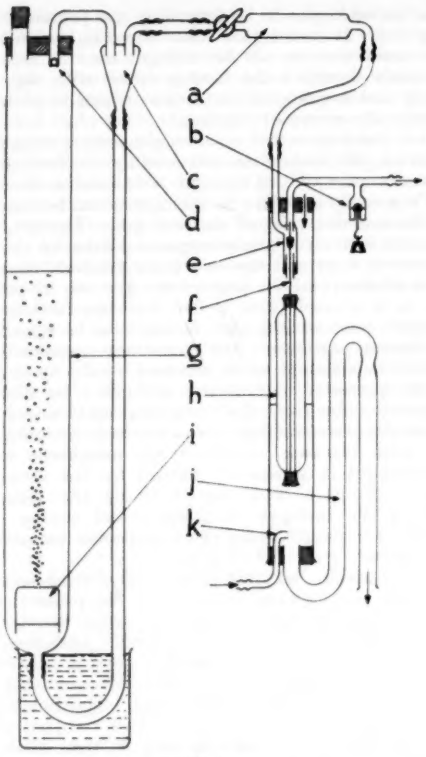

Fig. 1

pulse of ingoing air prevents the filter from getting damp and forces the foam in the conical flask (*c*) back into the medium.

Inoculation and sampling of specimens are done by means of a hypodermic syringe, the needle of which is pushed through the rubber tubing leading to the bottom of the growth vessel. When not in use, the point of attachment between the rubber tubing and the glass vessel is immersed in a beaker containing 70 per cent alcohol. All glass nozzles for rubber tubing should be silicone-coated or rubber cement should be used to prevent the culture from entering any capillary spaces.

An arrangement for introducing air at atmospheric or negative pressure in alternation can, of course, be constructed in many ways, but the simple glass device illustrated has proved quite adequate. Alternating air pressure in the system is provided by the rise and fall of a water surface, which in turn depends on the relation between a water flow (*k*) and a siphon capacity (*j*). An air-filled flask (*h*) floats on the water surface and actuates a simple two-way valve, consisting of a rubber stopper (*e*) attached to a metal rod (*f*). The rubber stopper intermittently closes one or the other of two glass tubes, one giving access to the open air, the other to a vacuum line with a valve (*b*) which can be loaded to give the desired vacuum.

It should be pointed out that the culture is under a varying but always slightly negative pressure. This helps to keep the filter dry, but more essentially, it reduces the risk of pathogens escaping through possible leaks. The maximum negative pressure used has been in the order of 120 mm. mercury.

That the aeration is good in spite of the negative pressure was found in tests where the oxidation of sulphite was followed[3,4]. In duplicate runs carried out at 20° C. with 1 litre of 0·5 *N* sodium sulphite and only six suction pulses per minute having a negative pressure of no more than 120 mm. mercury, it was found that 6 ml. of oxygen were absorbed per 100 ml. solution in the first 15 minutes, 9 in 30, 13 in 45 and 16 in 60 minutes. If excessive oxygenation is desired the device may be operated at two high-pressure levels, but this cannot be encouraged in the case of pathogens.

It is obvious that the aeration is influenced by the capacity of the airline which is common for ingoing and outgoing air. This has a very useful consequence. By changing the capacity of this line, that is, by interposing an empty or semi-empty flask, the 'active aeration' can be varied between zero and that maximal for the system. This means that the carbon dioxide-retention can be varied easily without alterations in the bubble-stirring. This is in fact quite vigorous because of the elongated shape of the growth vessel, which makes possible the use of high liquid heads. However, the principle is, of course, also applicable to other kinds of vessels, and it should, for example, be quite easy to provide ordinary fermenters with an 'internal foam circuit' of the type described.

Studies on the growth of different pathogens in the equipment will be published elsewhere. Very high yields of, for example, *Haemophilus pertussis* have been obtained.

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A Peritrophic Membrane in Calanoid Copepods

Forster[1] has recently examined the peritrophic membrane in Caridea (Crustacea, Decapoda). He found a membrane in the mid-gut of all the Caridea examined and was able to show that it was chitinous. A similar membrane can easily be shown to surround the fæcal pellets of calanoid copepods, where it often forms a 'tail', occasionally of considerable length, at each end of the pellet. That the pellet is indeed enclosed in a membrane can easily be demonstrated by compressing it carefully under a coverslip on a microscope slide. As pressure is applied the pellet first flattens more or less evenly throughout its length; then the membrane suddenly ruptures at one point only and its contents can be seen streaming through the point of rupture. The membranes can also be demonstrated by careful heating of a pellet in a concentrated potassium hydroxide solution: the alkali dissolves most of the fæcal matter, leaving the membrane intact. No positive results were obtained in tests for chitin but this may well be because of the small size of the pellets (*c.* 1·5 × 0·15 mm.) and the delicacy of the membrane.

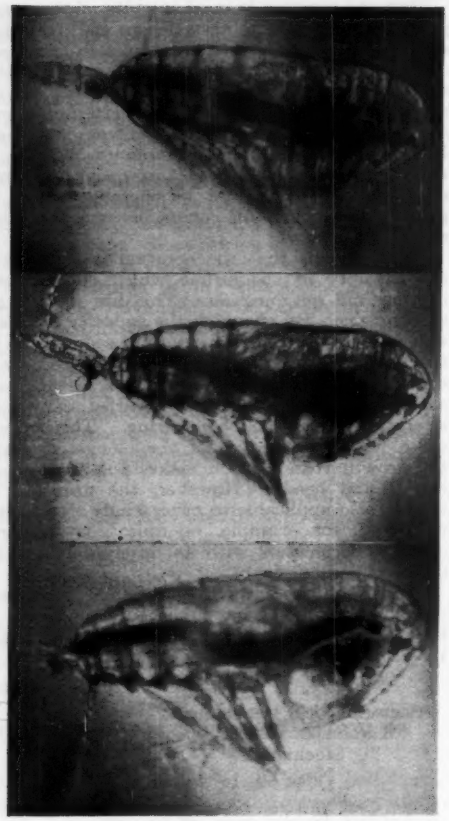

Fig. 1

Before discussing the formation and function of the membrane, it is necessary to describe briefly the structure and movements of the mid-gut. Histologically, the mid-gut is divided into three well-defined regions[2,3]: (*a*) an interior part, including the cephalic diverticulum, lined by cubical non-vacuolated cells; (*b*) a glandular region with large columnar vacuolated cells, occupying the first two thoracic somites, and (*c*) a posterior region of cubical non-vacuolated cells.

It is easy to observe movements of the gut of a living copepod, and, when it has been feeding actively, it is obvious that functionally the mid-gut is divided into two parts (Fig. 1*a*). In the anterior part the gut contents are loose in texture and being churned up by vigorous peristaltic movements; the posterior half is much less active and its contents are much more compact. The division between these two parts falls approximately at the end of the second thoracic segment, that is, at the posterior end of the glandular region of the mid-gut. From time to time the material in the posterior part of the mid-gut is passed backwards through the urosome and out of the anus, usually in a single, smooth movement. Once the pellet has been egested, the food in the anterior part of the mid-gut is spread over its whole length by three or four vigorous peristaltic waves (Fig. 1*b*). The gut contents are divided again into two parts, peristalsis continues in the anterior part while a new faecal pellet begins to be formed in the posterior part (Fig. 1*c*). It seems clear that there is here a clear functional division of the mid-gut into an anterior 'stomach' in which the food is mixed with digestive juices and a posterior 'intestine' which is probably mainly absorptive in function.

If a *Calanus* is fed on a suspension of congo red particles, the membrane surrounding the food in the posterior part of the mid-gut is stained a clear red and can easily be seen; no membrane can be detected in the anterior part of the mid-gut. Further, if a *Calanus* with a full gut is transected between the two masses of food and the two parts crushed, the contents of the posterior part of the gut can be pushed out as a normal faecal pellet, but the food in the anterior part of the gut emerges as a stream of incoherent particles. The membrane appears to be formed *in situ* and to be secreted by the epithelium of the posterior half of the mid-gut. In this the copepods differ from the Cirripedia[4] and Caridea[1], in which the membrane lines the whole of the mid-gut, and from *Daphnia*, in which the membrane lining the mid-gut is apparently formed by the fore-gut[5]. Dakin[2] found a 'rod' border lining the posterior part of the mid-gut of *Calanus* and similar 'rod' borders are found under the peritrophic membranes of Insecta[6].

The function of the peritrophic membranes of Insecta[6] and Caridea[1] is stated to be protection of the delicate mid-gut epithelium from damage by hard or sharp particles in the food. This does not seem to be the case in calanoid copepods, in spite of the fact that diatoms, which have siliceous frustules, form so large a part of their food. The function is apparently to contain the faeces in a compact pellet and its value to the animal may be that, since the relatively large and dense pellets sink much more rapidly than the phytoplankton which forms most of their food, the indigestible remains of the food are rapidly removed from the water in which the animals are feeding and are not ingested over and over again with fresh food.

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Double Monster Ephyrae of *Aurelia aurita*

A normal scyphistoma, taken with many others from a tank in the aquarium of the Marine Station at Millport, produced numerous normal ephyrae and two double monsters.

On April 17, two ephyrae were liberated together but could not tear apart. They were joined along the oro-aboral axis, the exumbrellar pole of one being attached to the aboral pole of the other. The contraction of the two bells was synchronous; the larvæ could be recognized distinctly as two individuals and swam about actively. Two days later the process

of regulation was under way; the animals slid over each other, gliding around the polar axis, the original polarity was maintained and the two manubria fused into one. The fused manubria had eight lips to begin with, but their number gradually decreased to four lips and eight tufts of gastral filaments. Regulation was not complete, since the two larvæ did not produce a single large disk with sixteen lappets, but remained open along a radial slit. The lappets were thus arranged in a spiral. The direct consequence of this was that pulsation was no longer annular and that a wave of contraction passed along the margin. The margin being spiral, the monster screwed itself continuously through the water. This specimen had seventeen lappets.

On April 19, a second double monster was produced by the same strobila; it was similar to the first, but had only fifteen lappets. Self-regulation proceeded exactly as in the first specimen. In the same finger-bowl normal ephyrae were in the meanwhile produced by other scyphistomes that had been taken from the same aquarium.

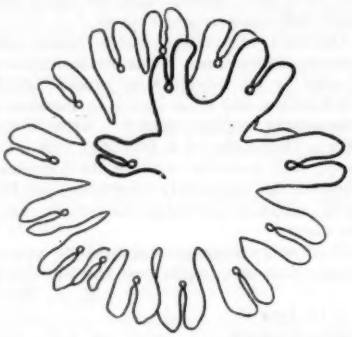

Fig. 1. Aboral view of double monster ephyra of *Aurelia aurita* with seventeen marginal lappets

I made several attempts to produce double monsters experimentally, but they were all unsuccessful. On cutting off the distal pair of ephyrae, the twinned larvæ swam together for a few hours then tore apart, thereafter leading an independent existence as normal larvæ. Longitudinal cuts, made in the strobila before liberation of the larvæ, did not produce monsters; the experimental ephyrae regulated themselves later while swimming independently. The cuts made in different directions all had similar results (and all larvæ regulated themselves after liberation).

A few other abnormal ephyræ were produced by other scyphistomes, all with a smaller number of lappets than normal. I believe the cause of this phenomenon may have been the relatively high room temperature, which varied between 15° and 20° C.

I have found no record of double monster ephyrae in the literature, but scyphistomes with double pedal disks were described by Hérouard[1]. Child[2] described experimental reconstitution of the scyphistome of *Aurelia aurita* and Browne[3] the variation in the number of tentaculocysts (marginal lappets) of the ephyrae of this species: they all regulated before reaching the adult stage.

The two double monsters here described died suddenly on April 23, when six and four days old respectively.

This work was done while holding a Unesco fellowship and was partly supported by a grant of the National Research Council of Brazil.

M. Vannucci

Oceanographic Institute,
P. O. B. 9075,
S. Paulo.
Dec. 27.

[1] Hérouard, E., *Bull. Soc. Zool. Fr.*, **45**, 162 (1920).
[2] Child, C. M., *Phys. Zool.*, **24**, 177 (1951).
[3] Browne, E. T., *Quart. J. Micr. Sci.*, **37**, 245, table 25 (1895).

Medial Defects of the Cerebral Arteries of Some Mammals

In 1930, defects were described[1] in the muscle of the media of the cerebral arteries of man. They were found in the fork of bifurcations and lateral branchings. These defects have been considered by some to be the major etiological factor in the pathogenesis of intracranial aneurysms which occur so commonly in man and yet are rare in other animals. As I have been unable to find reference in the literature to any similar study in other species, an investigation was commenced in 1954 to confirm or deny their existence in the dog, horse and sheep. This communication is prompted by a comment in a recent book[2] suggesting the advisability of such an investigation.

The cerebral arteries of six adult dogs were dissected for study and, after formalin fixation, serial paraffin sections were prepared of 115 major bifurcations and forks. All sections were stained by Verhoff's elastic tissue stain, and with good differential counterstaining with eosin the muscle of the media and the fibrous tissue of the adventitia could be clearly distinguished. Of the 115 forks, 85 had a medial defect and in another seven defects were only partial. There was no significant difference in their incidence in each of the six dogs. While only major forks and angles were considered primarily, it was noticed that defects also occurred very commonly in small branches as they arise from the large vessels, or as they dichotomize.

On reviewing the sites of the forks where defects existed, it appeared that they tend to occur principally at bifurcations forming an acute angle or one only slightly greater than 90°; the wider the angle, the smaller and less frequent the medial defect. The defects vary in size; sometimes they may be 100μ wide and usually the media ends abruptly on either side of the defect, which is composed of collagen and elastic fibrils.

The brain of an old horse was dissected, the cerebral arteries removed and serial sections of the forks prepared as described for the dogs. In all, thirty forks were examined and all showed complete medial defects except one, where there was only partial interruption of the muscle. Again, defects were frequent in the small vessels but they are not included in the above figures.

In the major work still in progress, defects similar to those occurring in man, dog and horse have been seen quite frequently in the sheep.

The above findings raise the problem as to why cerebral aneurysms are not so common in domestic animals as in man, for the histology of the arteries of these species is quite similar. It seems, then, that

medial defects are not the sole factor in the etiology of aneurysms of the intracranial arteries.

A detailed account of this investigation and other findings related to this work will be published at a later date. I wish to thank Mr. T. M. Jones for his painstaking technical assistance.

W. E. Stehbens

Department of Pathology,
University of Sydney,
Sydney.
Nov. 8.

[1] Forbus, W. D., *Johns Hopkins Hosp. Bull.*, **47**, 239 (1930).
[2] Walton, J. N., "Subarachnoid Hæmorrhage", 225 (E. and S. Livingstone, Ltd., Edinburgh and London, 1956).

Diseases of Cultivated Mushrooms

Recent articles and publications dealing with diseases of the cultivated mushroom make reference to the fungus known under the name of 'red *Geotrichum*' and 'lipstick mould'. This fungus, which is a competitor in the compost with mushroom spawn, is invariably referred to as *Geotrichum* sp.

It seems worth recording that a preliminary investigation was started on this disease in our laboratory in 1949 and the fungus isolated in pure culture. Various cultures were forwarded from time to time to the Commonwealth Mycological Institute, the type culture being retained as Herb. I.M.I. 45638. The fungus was identified by Mason and Hughes as *Sporendonema purpurascens* (Bonorden) Mason and Hughes comb. nov. (≡ *Coprotri chumpurpurascens* (Bonorden)[1] ≡ *Geotrichum purpurascens* (Bonorden) Sacc.[2].

The reason for removing the fungus from *Geotrichum* is that, if the practice of identifying *Geotrichum candidum* Link (the type of *Geotrichum*) with *Oospora lactis* (Fresen.) Sacc. is correct, Bonorden's fungus is not a *Geotrichum*.

The new combination was published by the late Prof. F. T. Brooks[3].

F. C. Wood

W. Darlington and Sons, Ltd.,
Southcourt Road,
Worthing. Nov. 17.

[1] "Handbuch der Allgemeinen Mykologie", 76 (1851).
[2] "Sylloge Fungorum", **4**, 40 (1886).
[3] "Plant Diseases", 2nd edit., 382 (1953).

African Pleistocene Pluvials and Pleistocene Glaciations

Dr. O. Davies's communication under the above heading[1] is of great interest and calls for comment.

In Uganda there is good evidence that the Kanjeran pluvial (old upper Kamasian) as established by Leakey is as distinct from the old Lower Kamasian as the latter is from the Kageran.

Factual evidence points to the conclusion that the Kagera River, on the border of Uganda and Tanganyika Territory, dried up during the Kamasian–Kageran interpluvial; but there is nothing to show that it ever did so before or after that event. Certainly it did not during the so-called Kanjeran–Gamblian interpluvial; but one cannot be dogmatic with regard to the two interpluvials that preceded the Kamasian, for two there were, according to the Uganda evidence.

In addition to the riverine support, we have the testimony of a wind-borne deposit containing three boulder-rubble incursions of great disorder. They seem clearly to indicate the effect of 'cloud burst' torrents which appear at intervals in an arid environment. More than this, in a small hanging valley, tested by a long trench and a 65-ft. deep shaft, a succession of talus deposits, separated by stoneless material, was discovered, and in this the Kamasian–Kanjeran contributions are seen to be from three to six times as great as the other two scree accumulations which record interludes, or intrapluvial phases. An important point to notice is this: had I not undertaken excavation (exhaustive within limits), and had not the little stream, now quite dry, produced the gulley (Solomons Gulley, I call it), it could truthfully be said that no evidence of an interpluvial phase between the old lower and upper Kamasian is known in Uganda, but clearly, that would not prove its absence.

Prehistorians (as apart from archæologists, *sensu stricto*, who have their own technique) will not excavate except in a minor way, or to dig caves, and until they learn to 'bung a hole down', as the old-time prospectors say, and even to drive an adit on occasion, in a spot which calls for such procedure, prehistory will miss a great deal.

But Davies's important letter raises two other points for consideration: What is admissible evidence of a pluvial or an interpluvial phase? And how is one to determine the time factor in mineral addition or metasomatic replacement? One investigator, observing a thickness of a hundred feet of calcrete, let us say, will roundly declare its formation must have occupied an extremely long time; another, more chemically minded perhaps, may take an entirely different view.

A well-chosen committee should be appointed to investigate what one might call the pluvial problem.

E. J. Wayland

C/o P.O. Box 9,
Entebbe, Uganda.

[1] *Nature*, **178**, 757 (1956).

Soil Thermometers

Garvitch and Probine have quoted errors they had found for soil thermometers when checking their calibration at low temperatures. All their thermometers were from one manufacturer[1].

We have tested a number of these thermometers, from various makers, but with somewhat different results. We found that at temperatures of 30° F. or below about half our thermometers read too high, but that at 40° F. very few were in error (though one of these read 5° F. too high at 40° F.).

In those thermometers for which the error was considerable, the paraffin wax lagging was replaced by a micro-crystalline wax of greater plasticity. On re-testing, it was found that the errors had disappeared. We are indebted to the British Petroleum Research Station for advice in the selection of a suitable replacement for the paraffin wax.

J. MacDowall

Instrument Division,
Meteorological Office,
Air Ministry,
Headstone Drive,
Harrow, Middlesex.
Nov. 16.

[1] *Nature*, **177**, 1245 (1956).

FORTHCOMING EVENTS

(Meetings marked with an asterisk • are open to the public)

Monday, February 11

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. C. D. Darlington, F.R.S.: "Determinism and Uncertainty in Genetics".

ILLUMINATING ENGINEERING SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 6 p.m.—Sir Lawrence Bragg, F.R.S.: "Some Experiments on the Interference of Waves" (Fourth Trotter-Paterson Memorial Lecture).

INSTITUTION OF ELECTRICAL ENGINEERS, LONDON GRADUATE AND STUDENT SECTION (at Savoy Place, London, W.C.2), at 6.30 p.m.—Dr. J. Eccles: "The Visit of the British Electricity Supply Delegation to the Soviet Union".

Tuesday, February 12

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. W. K. Taylor: "Experiments with Machines Capable of Learning".•

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS (at 6 Buckingham Gate, London, S.W.1), at 5.30 p.m.—Mr. C. S. L. Frances: "Jungle Clearance and Reclamation".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND RADIO SECTIONS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. M. E. Haine and Mr. M. W. Jervis: "The Ultimate Performance of the Single-Trace High-Speed Oscillograph", and "The Design and Performance of a New Experimental Single Transient Oscillograph with Very High Writing-Speed".

INSTITUTION OF THE RUBBER INDUSTRY (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. J. R. Happer: "Comparison of Different Types of Heating in the Rubber Industry". 7 p.m.—Mr. S. D. Sutton: "Dipped Goods Processing and Production".

ROYAL SOCIETY OF MEDICINE. EXPERIMENTAL MEDICINE AND THERAPEUTICS SECTION (at 1 Wimpole Street, London, W.1), at 5.30 p.m.—Prof. C. A. Keele: "Chemical Causes of Pain and Itch" (Presidential Address).

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at 14 Belgrave Square, London, S.W.1), at 5.30 p.m.—Mr. D. E. B. Greensmith: "Some Aspects of British Standards in Relation to Chemical Engineering in the Chemical Industry".

ROYAL AERONAUTICAL SOCIETY (joint lecture with the HELICOPTER ASSOCIATION OF GREAT BRITAIN, at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. O. L. L. Fitzwilliams: "Vibration Problems Associated with the Helicopter".

Wednesday, February 13

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. A. Hudson Davies: "The Development and Use of Glass Fibres".

EUGENICS SOCIETY (at Manson House, 26 Portland Place, London, W.1), at 5 p.m.—Prof. Tage Kemp: "*The Galton Lecture* on Genetic-Hygienic Experiences in Denmark in recent Years".•

INSTITUTE OF FUEL (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Mr. C. H. Bosanquet: "The Rise of a Hot Waste Gas Plume"; and Mr. A. C. Best: "Maximum Gas Concentration at Ground Level from Industrial Chimneys".•

INSTITUTION OF ELECTRICAL ENGINEERS (at the Central Hall, Westminster, London, S.W.1), at 6 p.m.—Dr. T. E. Allibone, F.R.S.: "Nuclear Energy in the Service of Man" (Faraday Lecture).

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at 14 Belgrave Square, London, S.W.1), at 6.45 p.m.—Scientific Papers.

ROYAL INSTITUTE OF CHEMISTRY (at the Royal Institution, Albemarle Street, London, W.1), at 7 p.m.—Dr. B. P. Ridge: "Chemical Fibres and the Community".

Thursday, February 14

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (at the Royal School of Mines, Prince Consort Road, London, S.W.7), at 4 p.m.—Dr. J. M. Lock: "The Magnetic Properties of the Rare Earth Metals at Low Temperatures".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Miss Honor B. Fell, F.R.S.: "The Effect of Excess Vitamin A on Cultures of Embryonic Chicken Skin Explanted at Different Stages of Differentiation"; Miss Margaret L. R. Harkness, Mr. R. D. Harkness and Mr. D. A. McDonald: "The Collagen and Elastin Content of the Arterial Wall in the Dog".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. C. H. Dowker: "Some Applications of Topology".

INSTITUTION OF ELECTRICAL ENGINEERS, UTILIZATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. P. J. Bhatt: "Self-Compensated Alternators"; Mr. D. Mangnall: "The Metal Rectifier and its Importance to the Electrical Engineer"; Mr. G. F. Stewart: "The Automatic Factory".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. W. J. Whelan: "The Synthesis and Degradation of Polysaccharides".• (Eleventh of fifteen lectures on "The Scientific Basis of Medicine", organized by the British Postgraduate Medical Federation.)

UNIVERSITY OF LONDON (in the Meyerstein Lecture Theatre, Westminster Medical School, Horseferry Road, London, S.W.1), at 5.30 p.m.—Dr. E. Weston Hurst: "Approaches to the Chemotherapy of Virus Diseases".• (Further lecture on February 15.)

ROYAL AERONAUTICAL SOCIETY (at the Institution of Mechanical Engineers, Birdcage Walk, London, S.W.1), at 6 p.m.—Mr. R. L. Lickley and Mr. Peter Twiss: "The Fairey Delta".

SOCIETY OF INSTRUMENT TECHNOLOGY, CONTROL SECTION (at Manson House, Portland Place, London, W.1), at 6 p.m.—Annual General Meeting. Mr. K. G. Crack: "A Servo Speed-Control for a Camera Crane".

CHEMICAL SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 7.30 p.m.—Prof. C. K. Ingold, F.R.S.: "The Course of Polar Reactions in Non-Polar Conditions".

Friday, February 15

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 12.45 p.m.—Annual Meeting. Dr. Alastair Heron: "Psychology, Occupation and Age" (Chairman's Address).

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Mr. D. O. Fraser: "Navigation and Traffic Control Over the North Atlantic".

INSTITUTION OF MECHANICAL ENGINEERS (in conjunction with the British Nuclear Energy Conference, at Church House, Westminster, London, S.W.1), at 6 p.m.—Sir Claude Gibb, F.R.S.: "Some Engineering Problems in the Industrial Development of Nuclear Energy" (Thomas Hawksley Lecture).

PHYSICAL SOCIETY, ACOUSTICS GROUP (joint meeting with the NON-DESTRUCTIVE GROUP of the INSTITUTE OF PHYSICS, at the Institute of Physics, 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. R. W. B. Stephens: "Acoustics in Non-destructive Testing".

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Reading of Original Papers by Members.

UNIVERSITY OF LONDON (at the Royal Holloway College, Englefield Green, Surrey), at 8.15 p.m.—Dr. E. J. H. Corner: "Botanizing with Monkeys".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. Margaret Mead: "The Study of Social Evolution".

Saturday, February 16

BRITISH INTERPLANETARY SOCIETY (at the Polytechnic, Regent Street, London, W.1), at 6 p.m.—Dr. J. Diederichsen: Chemical Demonstration of the Chemical and Physical Properties of Rocket Propellants.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned.

SENIOR LECTURER or LECTURER (with at least a good honours degree of a British university and prepared to teach inorganic and/or physical chemistry to Part II of the Graduate Membership Examination of the Royal Institute of Chemistry) IN CHEMISTRY—The Principal, Stockport College for Further Education, Wellington Road South, Stockport (February 16).

UNIVERSITY DEMONSTRATOR or UNIVERSITY ASSISTANT LECTURER IN THE DEPARTMENT OF GEOGRAPHY—The Secretary of the Appointments Committee, Department of Geography, University of Cambridge, Downing Place, Cambridge (February 16).

LECTURER (preferably interested in the experimental aspects of ecology or taxonomy) IN BOTANY at St. Salvator's College—Joint Clerk to the University Court, College Gate, St. Andrews (February 18).

LECTURER IN THE COMPUTING LABORATORY, to advise and instruct prospective users of the automatic computer in the Laboratory—The Registrar, University of Durham, 1a Kensington Terrace, Newcastle-upon-Tyne 2 (February 23).

LECTURERS IN MATHEMATICS—The Registrar, King's College, Newcastle-upon-Tyne (February 23).

ASSISTANT LECTURER IN PHYSICS—The Registrar, University College, Leicester (February 28).

ASSISTANT LECTURER (with an honours degree and preferably with postgraduate experience in mycology or microbiology) IN BOTANY; and an ASSISTANT LECTURER (with an honours degree) IN PHYSICS—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (February 28).

CHAIR OF STATISTICS WITHIN THE DEPARTMENT OF PURE MATHEMATICS; and a CHAIR WITHIN THE DEPARTMENT OF CHEMICAL ENGINEERING—The Registrar, The University, Birmingham 15 (February 28).

LECTURER IN PURE MATHEMATICS—The Registrar, The University, Nottingham (February 28).

LECTURER (with interests in metamorphism or structural geology) IN THE DEPARTMENT OF GEOLOGY—The Secretary, The University, Edinburgh (February 28).

LECTURER or ASSISTANT LECTURER (with qualifications in the field of mathematical analysis) IN PURE MATHEMATICS—The Registrar, The University, Hull (February 28).

LECTURERS (2) IN THE DEPARTMENT OF ORGANIC CHEMISTRY—The Registrar, The University, Liverpool (February 28).

LECTURER or ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Secretary, The University, Exeter (March 1).

LECTURER IN THE DEPARTMENT OF PHYSICS; and an ASSISTANT IN PHYSICS—Joint Clerk to the University Court, Queen's College, Dundee (March 20).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN BIOCHEMISTRY, CHEMISTRY, CHEMOTHERAPY, ENGINEERING, METALLURGY, PHARMACOLOGY, PHYSICS, and subjects allied to CHEMISTRY OR PHYSICS—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

TURNER AND NEWALL RESEARCH FELLOW IN ENGINEERING, INORGANIC CHEMISTRY, PHYSICS, or an allied subject—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

ANALYST (with at least H.N.C. in chemistry) IN THE INORGANIC SECTION OF THE ANALYTICAL DEPARTMENT, for work which includes the complete analysis of coal ashes, slags, boiler deposits and minerals —The Assistant Secretary, Ref. D.1, British Coal Utilization Research Association, Randalls Road, Leatherhead, Surrey.

ASSISTANT (analytical chemist with several years experience in analytical work) IN THE CLINICAL BIOCHEMISTRY DEPARTMENT—The Director of Pathology, Queen Elizabeth Hospital for Children, Hackney Road, London, E.2.

ASSISTANT, Grade B (with suitable academic qualifications), IN MATHEMATICS to teach up to final degree standard—The Principal, West Ham College of Technology, Romford Road, Stratford, London, E.15.

BIOCHEMIST or CHEMIST, Scientific Officer or Senior Scientific Officer grade (preferably with previous experience in protein chemistry or with isotopic tracers), to study the protein and protein-like substances of leaves, with a view to a more detailed characterization and elucidation of metabolic relationships—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire.

CHAIR OF ENGINEERING MATHEMATICS IN THE DEPARTMENT OF MATHEMATICS—The Professor of Mathematics, Queen's University, Kingston, Ontario, Canada.

COMPUTER (aged under 40, with a degree in mathematics) IN THE LANDS AND SURVEY DEPARTMENT, Government of Tanganyika, for the computation of surveys of a geodetic, astronomical or cadastral nature, and the keeping of records—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.107/8/06.

CURATOR (Ph.D. or equivalent, with specialized training in palæontology) OF GEOLOGY, for duties which include the classification and organization of university collections of fossils, rocks and minerals; with an additional light teaching load and responsibility to carry out research work—The Chairman, Department of Geology, Hamilton College, McMaster University, Hamilton, Ontario, Canada.

LABORATORY ASSISTANT (preferably with a pass in any biological subject at advanced level of the general certificate of education) IN THE BIOLOGY LABORATORY—The Principal, Kingston Technical College, Fassett Road, Kingston-on-Thames.

MATHEMATICIANS, AERODYNAMICISTS and AERO-ENGINEERS (with, or obtaining, a first- or second-class honours degree in mathematics or engineering, or equivalent qualifications) at a Ministry of Supply Experimental Establishment, for duties which include research and investigations into problems of aircraft performance, stability and control; application of mathematical techniques to problems relating to aerodynamics, structure, navigation, armament, etc.; and assessment in connexion with performance estimation of new types of aircraft—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.421/6A.

PALÆONTOLOGIST (with a first- or good second-class honours degree in geology, and at least two years postgraduate work in palæontology) IN THE GEOLOGICAL SURVEY DEPARTMENT, Government of Cyprus, to identify fossils and micro-fauna in order to determine the age of sedimentary formations, and to assist in the mapping of fossiliferous horizons—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/17/03.

PHYSICIST to be concerned with dosimetry and physical investigations arising in therapy with X-rays and radioactive sources—The Secretary, Institute of Cancer Research, Royal Cancer Hospital, Fulham Road, London, S.W.3.

PROFESSOR AND HEAD OF THE DEPARTMENT OF CHEMICAL ENGINEERING—Dean H. C. Gunning, Faculty of Applied Science, University of British Columbia, Vancouver 8, B.C., Canada.

SENIOR LABORATORY STEWARD IN THE CHEMISTRY AND BIOLOGY DEPARTMENT—The Registrar, College of Technology, Park Road, Portsmouth.

SENIOR LECTURER (with a university degree in engineering or physics, and preferably with appropriate industrial or research experience) IN REFRIGERATION, at the National College for Heating, Ventilating, Refrigeration and Fan Engineering—The Clerk to the Governors, Borough Polytechnic, Borough Road, London, S.E.1.

SENIOR LECTURER (with research experience and preferably industrial experience) TO TEACH ORGANIC CHEMISTRY to the standard of the B.Sc. (Special) Chemistry and A.R.I.C.—The Principal, Technical College, Queen Street South, Huddersfield.

STAFF COMPUTER (with an honours degree in mathematics) IN THE LANDS AND SURVEY DEPARTMENT, Government of Uganda, for the computing of all types of survey; assisting in training of junior staff; and to take charge of the Computing Office in the absence of the Senior Staff Computer—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.107/9/01.

TECHNICAL ABSTRACTOR (with an interest in technical library and information work, and preferably with a degree in chemistry, and experience in the preparation of informative abstracts and literature surveys) IN THE INTELLIGENCE SECTION—The Intelligence Officer, Coal Tar Research Association, Oxford Road, Gomersal, near Leeds.

VICE PRINCIPAL (with good academic and administrative ability), to take responsibility, under the Principal, for the administration of the College, and will have a particular interest in the large building programme now commencing—The Principal, Technical College, Queen Street South, Huddersfield.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Medical Research Council. Special Report Series, No. 292: A Study of Attitudes to Factory Work. By S. Wyatt and R. Marriott, assisted by R. A. Denerley, H. Campbell, J. Walker, Yvonne Kapp, and F. G. L. Stock. Pp. vii+115. (London: H.M. Stationery Office, 1956.) 10*s.* net. [1412

Medical Research Council Memorandum No. 33: An Annotated Catalogue of the Mutant Genes of the House Mouse. By H. Grüneberg. Pp. v+28. (London: H.M. Stationery Office, 1956.) 2*s.* 6*d.* [1412

British Gelatine and Glue Research Association. Eighth Annual Report for the year October 1955 to September 1956. Pp. 16. (London: British Gelatine and Glue Research Association, 1956.) [1412

Bulletins of Marine Ecology (formerly Hull Bulletins of Marine Ecology). No. 34, Vol. 4: An Ecological Survey of the Drift-Net Herring Fishery Off the North-East Coast of Scotland. Part 1: On Sampling by the Commercial Fishing Fleet. By R. S. Glover, G. A. Cooper, and W. W. Brown. Pp. 141–178. (Edinburgh: Scottish Marine Biological Association, 1956.) 10*s.* [1412

Ministry of Housing and Local Government. Methods of Chemical Analysis as applied to Sewage and Sewage Effluents. Pp. vi+96. Second edition. (London: H.M. Stationery Office, 1956.) 10*s.* net. [1412

Other Countries

Indian Forest Bulletin (New Series). No. 194: Timber Mechanics. Working Qualities of Some Indian Timbers. By A. C. Sekhar. Pp. 1+9. As. 12; 1*s.* No. 196: Cellulose and Paper. Indigenous Cellulosic Raw Materials for the Production of Pulp, Paper and Board. Part 26: Chemical Pulps and Writing and Printing Papers from Blue Gum (*Eucalyptus Globulus* Labill). By R. V. Bhat and M. G. Karnik. Pp. ii+7. As. 9; 10*d.* Indian Forest Records (New Series). Vol. 10, No. 1: General Volume and Bark Outturn Tables for Babul (*Acacia Arabica*, Willd.). By G. S. Mathauda and M. M. Singh. Pp. ii+20. Rs. 1/4/–; 2*s.* (Delhi: Manager of Publications, 1956.) [712

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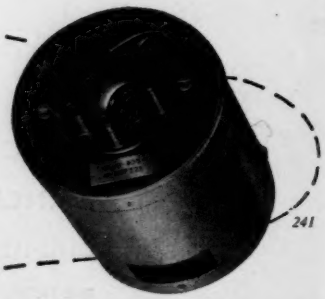

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